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# THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

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BULLETIN NO 50.

## Notes on Plum Culture.

*Approved by the Station Council,*

*ALSTON ELLIS, President.*

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FORT COLLINS, COLORADO.

DECEMBER, 1898.

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# NOTES ON PLUM CULTURE.

BY CHARLES S. CRANDALL.

Prefatory note on the application of horticultural rules.

There are certain general rules in the practice of horticulture that are capable of wide application. If we say that cherry trees should never be planted on wet or mucky soil, we state a general rule, equally applicable to any section of the country.

There are certain other rules, such as those governing the choice of varieties, selection of stocks, season for and manner of budding or grafting, time of planting and frequency of irrigation, that may be called specific rules. These are of necessity local in character and may be quite restricted in application.

Possibly no state presents greater diversity in local conditions that govern horticultural practice than does Colorado. Not only do wide differences exist between eastern and western sides of the Continental Divide, but either slope may be divided into sections that would warrant considerable differences in practice on many points, and then, each section may have peculiarities that would subdivide it. Even the differences between the two banks of a stream, or the varying soil conditions of two adjoining farms, may present factors that modify successful practice.

If a man moves from one section to another he will naturally attempt to grow the varieties and follow the methods with which he is familiar. He meets failure in many particulars and after a time learns by experience that his new surroundings call for different methods and likely different varieties. It has always been the experience in new countries that the pioneers in horticultural work made mistakes which they found expensive and discouraging, but by persistence they learned to avoid the early errors and finally

achieved success. Later comers can, and should, profit by the experience of these pioneers. The methods they have found successful can be safely followed, no matter how they differ from those successfully practiced elsewhere.

The specific rules to which I here refer are often discussed in public, and frequently the views expressed are very diverse. Two men may discuss a particular practice, each persistent in holding his honestly expressed conviction, derived from personal experience, to be the only correct one. Each knows he is right and no amount of discussion will bring them to the same view. The newcomer seeking information is confused by the opposite views so strenuously contended for. Transactions of societies and the horticultural press bear evidence that such discussions are not infrequent. The writer is of the opinion that in many cases these discussions do more harm than good, or are at least profitless, because they are dropped with the differences unexplained. Inquiry will often bring out differences in the local conditions under which the experiences have been acquired that will fully account for the diverse views expressed.

The idea that I would emphasize and urge upon those who contemplate entering upon horticulture as a business is, that a careful study should be made of all the conditions surrounding the particular place chosen. Sum up the experience of the pioneers, consider the liability to late spring frosts, and early fall frosts, to storms and winds. Examine into the water supply, soil, subsoil, slope, exposure, direction of prevailing winds, and every other feature that may have bearing upon future success. Attention to these factors will enable intelligent action, saving expense and avoiding disappointment.

I am lead to dwell in some detail upon this matter of the application of specific rules because so many requests for advice on the points enumerated are constantly being received. Usually inquiries are unaccompanied by any statement of local conditions or aims in view, and it is difficult, often impossible, to give the desired information except in the most general terms, and this is unsatisfactory both to the writer and to the seeker after information.

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#### DERIVATION AND DISTRIBUTION OF OUR PLUMS.

The genus *Prunus* as now constituted embraces those species from which have been developed all our stone fruits, Almonds, Peaches, Nectarines, Apricots, Plums and Cher-



ries. Its representatives are widely distributed over the earth and the number of species as given by different authors varies greatly. Bentham and Hooker in their *Genera Plantarum* place the number at about eighty. A later work, the *Index Kewensis*, recognizes 121 species, and records 290 names as synonyms. The 121 species here considered valid are distributed as follows:

Eastern hemisphere 87 species, 15 of which are credited to Japan and 12 to China. Western hemisphere 32 species, 21 of which belong to the United States and the region north. Seven are credited to Mexico and four to South America and the West Indies. Two species are recorded as of unknown origin.

Our American manuals record species of the genus as follows:

Botany of California (1876), 6 species.

Chapman's *Flora of the Southern States* (1883), 7 species.

Coulter's *Manual of the Rocky Mountain Region* (1885), 5 species, 1 variety.

Gray's *Manual*, 6th Ed. (1890), 10 species, 1 introduced variety.

Coulter's *Flora of Texas* (1891), 8 species.

The Britton and Brown *Flora* (1897), 16 native, 4 introduced species, 2 native and 1 introduced varieties.

Taken together these floras recognize 27 native and 4 introduced species, and 3 native and one introduced varieties.

Of the native representatives of the genus, 16 species and 1 variety are true plums, or of such close affinity as to readily class with them, while 11 species and two varieties are cherries or belong with the cherry group. Nearly all the species enumerated in the manuals are, or have been at some time, introduced into gardens and cultivated, either for their fruits or as ornamentals, but the varieties now catalogued by nurserymen and grown in orchard, represent but few species. Of the native cherries only the shrubby sand-cherries (*Prunus pumila*, *P. Besseyi*, and *P. cuneata*) are grown for fruit. The Wild Red Cherry (*P. Pennsylvanica*) is occasionally used as a stock upon which the common sour cherries, of European origin, are grafted; it has also been used to a limited extent as a stock for some of the plums.

Of the native plum group, three species (*P. Americana*, *P. hortulana* with its variety *Mineri*, and *P. angustifolia*) have furnished nearly all of the cultivated varieties. The Beach plum (*P. maritima*) is the parent of but one variety of



doubtful value. The Mariana so largely used for stocks, and the De Caradeuc are closely related, but of uncertain origin. A few varieties are probably hybrids, although the manner in which most of them originated is more a matter of speculation than of definite knowledge. There are still other varieties that cannot even be classed as hybrids and whose ancestry is likely to remain undetermined. Professor Bailey of Cornell, who has given the whole plum group careful study, arranges the native varieties into groups as follows:\*

The American Group—*Prunus Americana*.

The Wild Goose Group—*Prunus hortulana*.

The Miner Group—*Prunus hortulana* var. *Mineri*.

The Chicasaw Group—*Prunus angustifolia*.

The Mariana Group—Of uncertain origin. De Caradeuc assigned to *Prunus cerasifera*, and Mariana thought to be a hybrid.

The Beach Plum—*Prunus maritima*.

The Wild Plum of the Pacific Coast—*Prunus subcordata*.

Hybrids, unclassified varieties—Of uncertain origin.

Our foreign introductions belong to two groups:

The European Plums, such as Lombard, Green Gage, and the numerous prunes—*Prunus domestica*.

The Japanese Plums—*Prunus triflora*.

While the European plums can be grown in some sections, the tender nature of the fruit buds makes them uncertain on the eastern slope, except in favored localities, and dependence must be placed mainly upon the Americana varieties. In the fruit districts of the western slope the Wild Goose is eminently successful and stands at the head of the list of profitable varieties, but it is probably too tender for the eastern slope, certainly for the northern and central districts.

In general throughout the West the native plums are proving profitable. Even in districts where the domestica varieties are successfully grown, the native red plums sell in competition with them, and at remunerative prices. While it may be admitted that most native varieties are inferior in size and flavor to those of the domestica class it, should be remembered that the extended introduction of the natives is comparatively recent, that the improvement in them has been rapid, and that they offer wonderful possibilities in the direction of future development. All the

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\* See bulletin No. 38, Cornell Experiment Station.

better varieties are very productive. Some show a strong tendency to excessive production, a habit which if allowed to go unchecked, not only gives inferior fruit, but tends to shorten the life of the tree. With such varieties systematic thinning must be practiced in order to insure regular crops, and fruit of the largest size and best flavor. Then, having produced good fruit, if the grower will exercise the same care in handling that is given other fruits, and will place them on the market in the same attractive packages, the demand which already exists will be greatly stimulated.

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### PROPAGATION OF THE PLUM.

Most varieties of plums have come to us as seedlings selected and retained because of their good qualities; they show development or variation from wild types in varying degree, but with all, the departure is such that we can not reproduce them through the seed, and in order to maintain them we are forced to adopt other means.

All varieties are perpetuated by either budding or grafting, usually on plum stocks. The kinds available as stocks are various and exhibit as great differences as appear between the varieties to be propagated. No one stock can be regarded as perfectly satisfactory for general use with all varieties, and it follows that care and thought must be exercised in making choice of what shall be used.

The character of the soil, whether light or sandy, or verging on the other extreme of heavy clay, and the general features of the climate will largely govern this choice, but consideration must also be given to the characteristics of the varieties to be propagated.

The desirable varieties have parentage in widely different species, each of which has characteristics peculiarly its own. The derivative varieties follow more or less closely after the parent species, inheriting habits, likes and dislikes, which must be regarded if we achieve success in their management. Even among derivatives of the same species we may find varieties sufficiently different to call for the use of different stocks and different methods of treatment. This would be looked for among the varieties that have been under cultivation for the longest periods, and is due to the fact that the variation and development from the original type has not been along parallel lines. Differences in climate, in food supply, and in general environment have led to diver-



gence resulting in races which possess distinctive and well-marked characters.

Some knowledge, therefore, of the history and derivation of varieties is essential to the propagator in order that he may make intelligent selection of the stocks upon which to work his profitable varieties. Successful propagators, well versed in the history of varieties, and in the principles of culture will, however, often differ in their estimate of available stocks, just as they will differ on methods of practice. Strong growing varieties are not suited to very slow growing stocks because they over-top them and the trees are short lived. On the other hand success does not follow the attempt to force a slow-growing variety by working it upon a rank-growing stock. The nearer the variety to be grafted corresponds with the stock to be used in general habit and vigor of growth, the better will be the prospects for health and longevity in the tree.

Figures 1 and 2, Plate I, illustrate an overgrowing of the stock that is not uncommon. Figure 1 is a Yellow Sweet, (*Prunus Americana*,) planted in 1894. The enlargement just above the union is marked, and it is increasing each year. Figure 2 is a Wolf (*Prunus Americana*) tree of uncertain age, probably 14 or 15 years old, in which the enlargement is still more marked. We have no information as to the stocks used in either of these cases, but the fact that there is not perfect affinity between the varieties and their stocks is apparent.

For the European plums such as Lombard, Green Gage, and Bradshaw probably no stock is better than seedlings of some variety of the species from which these varieties came—*Prunus domestica*. These have been in common use for many years, but in recent years have been in some degree superseded by Myrobalan stocks (seedlings of *Prunus cerasifera*, a species of European origin). Myrobalan stocks are in common use in European countries and have rapidly grown in favor with our nurserymen, not because better trees can be grown upon them, but because it is easier to secure good Myrobalan than good domestica stocks. Seeds of domestica varieties that will produce an even stand of stocks is difficult to obtain, and the Myrobalan, which is easier to grow and less liable to injury from parasitic fungi, offers an acceptable substitute. Some nurserymen import the seeds and grow their own stocks, others find it more profitable to import the seedlings. They are usually received during the winter, planted in nursery rows in spring, and budded in July and August. In the south the stocks in



common use are the Marianna plum and the peach, and very diverse opinions as to their relative merits have been expressed. Probably the differences arise from varying local conditions, for the testimony at hand indicates that on the light and dry soils the peach stock does best, while the Myrobalan is better suited to the heavier and more moist soils. Even at the north the peach meets with some favor as a stock for plums on light soils, but it is too tender for districts where severe winters are common. For the native varieties, Wolf, Weaver, De Soto and other derivatives of *Prunus Americana*, the natural inference that Americana stocks would be best seems to be borne out by experience, but the degree of success may depend in a measure upon the seed used. The species is extremely variable in general habit and rapidity of growth as well as in the fruit produced. Seeds from which to grow stocks should be chosen from vigorous free-growing trees only. The progeny of such trees will most nearly accord with the varieties to be propagated and better insure the future of the tree. Seeds are obtained in the fall, separated from the pulp, mixed with sand and kept in a cool, moist place, during the winter. If they can be frozen and thawed several times, so much the better, for they will then more readily crack under the pressure of the swelling embryo.

In spring they are sown in seed beds of deeply stirred rich soil. In the fall the seedlings are lifted, sorted and packed away in sand in a cool pit or cellar. The following spring they may be planted in nursery rows to be budded in July and August. The commencement of the budding season is determined by the maturity of the scion buds to be used; they are buds of the current year's production and must be well matured. Budding may be continued as long as the bark will "slip," and this as well as the maturation of the scion buds will be largely influenced by weather conditions. The length of the budding season may, therefore, vary greatly in different years. Usually the season with plums is shorter than with peaches or apples. About ten days after insertion the buds should be examined and the bands loosened if necessary. Where buds have failed to unite, the stocks may be rebudded and this may be repeated as often as the length of the season will allow. Late in the fall stocks on which buds have failed should be taken up and stored for grafting in late winter or early spring. When growth starts in the spring the budded stocks must receive prompt attention. The stock must be "headed down," that is, cut off above the bud, and here practice varies somewhat.

Some growers prefer to cut from four to six inches above the bud, while others would at once cut as close to the bud as it is safe. The idea in cutting high is to leave a stub which may serve as a support to which the shoot from the bud may be tied, the stub being removed at the close of the first season's growth. All shoots below as well as above the scion bud must be removed, otherwise they will starve the bud by diverting the sap to their own development. Further production of these shoots from the stock will occur, and they must be frequently checked in order to secure the best growth of the scion.

By far the greater number of plum trees grown commercially are produced by this process of budding. It is the easiest and best way when trees are grown in quantity, but as good trees can be produced by grafting, and often it is more convenient to graft than to bud. Here at the station we have used both methods and have found grafting rather more uniformly successful than budding. During the budding season the weather is hot and dry, and frequently no water is available for irrigating; many buds dry out and fail to take, so that under conditions similar to ours the writer believes the method of propagating by grafting will give the best satisfaction, and particularly to the fruit grower who propagates in a small way for his own use. I am aware that the idea is current that stone fruits, and particularly plums, are difficult to graft. It is true that certain precautions must be observed that need receive little attention when grafting the apple, but these simple precautions taken, the work is no more difficult and success is as certain as with the apple. Of course the mechanical work of putting scion and stock together must be well done, but outside of this there are three points upon which success mainly depends:

1st—The perfectly dormant condition of both stock and scion at the time the operation is performed.

2nd—The protection of the union by coating with wax.

3rd—Proper care of the plants between grafting and setting in nursery.

The work is usually performed during March or April, and may be continued so long as the dormant condition can be maintained. Plums, however, start growth under slight stimulus, and a few warm days will end the work, even when all ordinary precautions have been taken. We have frequently filled the passage-way in our outside storage-pit with snow and ice as a means of keeping the temperature down, and have thus gained a few days. It is best to com-



mence early enough so that the finish need not be hurried by the weather conditions.

Scions must not only be dormant, but must be otherwise in good condition, neither wilted from drying, nor water soaked from being kept too wet. Sometimes it is convenient to take them from the trees as wanted; more frequently they will be cut late in the fall, or come from a distance, and the question of how to keep them will present itself.

They may be kept in an outside cellar or pit, packed in dry leaves, or in moss that is but slightly damp. The aim should be simply to provide conditions that will prevent the loss of moisture, without affording opportunity for the absorption of an excess.

The particular method of grafting to be used is much a matter of taste. Several are available, among which the four following are named in the order of the writers preference: Veneer, Side, Whip and Cleft.

The side graft is probably in more general use than any of the others, but after several years experience with all of them we are inclined to favor the veneer method as giving the most perfect union.

It is not our purpose to here discuss the principles of grafting, but may remark that in all grafting no union takes place between cut surfaces of the wood. It is only through the adjustment of the cambium of the scion to that of the stock that union is secured, and here, it is not a union between cells existing at the time the grafting is done, but through new cells formed in extension of the cambium, which is the only channel of communication between leaves and roots. This being true it seems reasonable that the less the area of cut wood surfaces the better. The minimum of cut wood is secured by the veneer graft, which only exposes the wood in the oblique transverse cuts at the apex of the stock and the base of the scion. The one valid objection that may be urged against the veneer graft is that the scion is easily displaced. It is easily displaced if carelessly tied, but with reasonable care no trouble need be feared.

Whatever the method used the union should be thoroughly covered with some protective wax. A liquid wax to be applied with a brush is most convenient, and of several preparations one known as "Alcoholic Plastic" answers the purpose admirably. It is made as follows: One pound of Resin, and one ounce of tallow melted together; remove from the fire, and after cooling slightly, but while still liquid, add eight fluid ounces of alcohol and stir thoroughly. This



preparation must be kept in a corked bottle or other closed vessel to prevent the evaporation of the alcohol.

After waxing, the grafted stocks should be returned to the cellar and kept at as low a temperature as possible without freezing until the time arrives for setting in nursery. The roots may be placed in damp sand, but the scions should be subjected to such a degree of moisture only, as will prevent drying out. The practice as here outlined is successfully followed in our station work. In all grafting of plums the scion should be set low on the crown so that when planted in the nursery the union may be placed well below the surface.

The plum is seldom worked above the ground, and there seems to be nothing in the practice to commend it for practical purposes. If it is attempted it should only be with varieties of close affinity, and trees of equal vigor. Scions from a slow-growing tree can not keep pace with the branches of a strong-grower, and if the strong scion is worked on the slower stock it soon out-grows it and the wind breaks it off. A scion of Indiana Red worked on a wild Americana stock three feet above the ground produced a straight whip five feet and four inches long; three feet above the union the new growth had the same diameter as the stock at the ground. It yielded to a moderate wind.

Sometimes when new varieties are procured for trial, a few scions are worked on old trees of some Americana variety with a view to obtaining fruit quickly. Thus trees of Ogon planted in 1894, have not yet fruited because the tops have killed back every year, but scions from the same trees, taken at the time of planting and worked on *Prunus Americana* have given us fruit for four seasons. Several other varieties treated in the same manner at the same time, have fruited, but all, or nearly all are now dead.

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### PRUNING.

Plums are pruned for the purpose of forming and maintaining a symmetrical, well-balanced top. Five or six branches, equally distributed about the stem, and having some vertical separation are selected to serve as a framework of the top. All others are removed and the leader is shortened. The branches retained should be cut back to some extent, but this, as well as the shortening of the leader must be determined for each tree, being dependent upon the root system and the apparent vigor. In shortening the branches

and leader, the cuts should be made with reference to selected buds so placed that the future extension may be in the right direction. During the summer, rub off shoots that start where they are not wanted, and pinch the tips of rampant branches. The second spring, before growth starts, the shoots produced the previous year should be shortened to encourage the production of secondary, interior branches, and the third year this is repeated. From now on no pruning is needed except to remove branches starting from wrong places, and to control the too vigorous branches. This is best done by summer pinching, and in general it may be said that the less the knife is used on plum trees, the better it is for the trees. Most varieties require very little pruning after the head is once formed.

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### SOILS.

Plums will adapt themselves to almost any soil that would be chosen for apples or pears. Domestica varieties are perhaps best on heavy clay, and choice may be more restricted with them than with most other sorts. The native varieties are suited to a wide range of soils, but no tree will do well on wet mucky soils, and as the plum is a rank feeder and a heavy bearer, the soil must be of good fertility.

Colorado soils are in general well adapted for the plum, but even on the best, good cultivation and the systematic application of fertilizers is to be recommended.

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### IRRIGATION,

Frequency in the application of water is so entirely dependent upon the character of the soil that no rule can be made to govern it. How best to irrigate must be learned by experience for each orchard. In a general way it may be said that young trees require more water the first season than is necessary in succeeding years. Trees that are bearing, however, should receive almost, if not quite as much, as young trees; it is necessary for the best development of the fruit.

The soil of our station orchard is quite compact; water does not spread quickly, and each irrigation is prolonged for a greater time than would be necessary on more porous soils. When water is available we aim to apply it once in



ten days for young trees; somewhat less frequently for those older.

The effects of drouth during July and August are frequently seen in small inferior fruit. Reasonable care in the application of water during this period will well repay the trouble in the increased quantity and better quality of fruit. It is, however, possible to apply an excess that may work as great injury as the most severe drouth. It is only by studying the appearance of the trees, and the condition of the soil that we can arrive at a correct adjustment of the quantity to be applied, and the time to apply it.

It is our practice here to withhold water after the first of September in order to check growth and allow the wood to ripen. If growing conditions are maintained through the fall the young and succulent wood, of even the hardiest varieties, is in danger of being killed by low winter temperatures, but if well ripened it survives the extremes without injury. Twice within the last six years we have had open winters that proved more productive of injury to trees than those of continuous cold. There were long periods of warm weather, with no frost in the ground, and no precipitation to supply the continuous evaporation. The soil became very dry and the trees suffered in consequence. To guard as much as possible against such injury it is the practice to give a late irrigation, usually in November. If the ground can be well saturated at this time it is of advantage to the orchard whether the months following be cold or warm; if warm, the soil will not so soon become dry, and danger from this source is lessened; if cold and the soil be continuously frozen, the moisture is retained and the conditions for spring growth improved.

The system practiced is to furrow for each irrigation, using a one-horse plow and turning from the trees on both sides of the row. Water is run in the furrows for from 12 to 36 hours according to the supply available and the condition of the soil. As soon as practicable after irrigating, a harrow is used to close the furrow and smooth the surface. The aim is to keep a constant mulch of loose soil on the surface so as to check evaporation as far as possible. The method of applying water is illustrated by plate 2.

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#### PLANTING DISTANCE.

Practice and opinion on the matter of distance between trees in orchard planting is very diverse. The general



tendency is toward too close planting and sometimes this is carried to extremes. I have seen several plum orchards planted 10x10 feet that even now when only five years old have much the appearance of thickets. Cultivation is impossible, the fruit is small and difficult to get at, insects find a safe harbor, and the whole arrangement is unsatisfactory and unprofitable. The condition grows worse with each year. In most cases the suggested remedy, removing alternate trees will not be followed until too late, if at all, and within a very few years the whole must of necessity be destroyed and the labor of planting lost.

The most common practice is to plant 15x15 feet, but this is too close for fully developed trees of spreading habit. A better plan is to plant 15x20 feet, or to adopt the accepted California practice and allow 20x20 feet. There seems to be a decided preference for low-headed trees on the ground that they are less liable to injury from winds, and that less trunk is exposed to the action of the sun. With low-headed trees the disadvantages of close planting are more quickly apparent. The best formed trees in the station orchard are those headed at from 30 to 36 inches from the ground, and this is the distance we prefer.

Young trees are frequently injured by what are known as "frost cracks," a longitudinal splitting of bark and wood on the south side of the trunk, occurring in late winter or early spring and attributable to the extreme daily range of temperature which often occurs at this season. To guard against this injury the trunks should be protected in some way. Various devices have been used, but we have found wrapping with burlap the most effective and least expensive. Burlap that had been used for baling was purchased at dry goods stores for two cents per pound and cut into four inch strips, three and four feet long; one pound giving as an average 9 strips. These are wound spirally on the trunks, being held at the top by a lap, and by tying with cord at the bottom. One man can cover from 50 to 60 trees per hour with the material prepared and ready at hand. The covering is applied in November and removed in April or May. The same bands will serve for two or three seasons. The whole cost is less than one cent per tree and well repays the trouble.

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#### ARRANGEMENT OF VARIETIES.

The Wild Goose plum has long been regarded as infertile when isolated and the same complaint has occasionally

been made regarding other varieties, but the experiments carried on by Professor Waugh of Vermont, in 1896 and 1897, indicate that the actual extent of self-sterility among varieties of plums, has by no means been appreciated or even suspected. His tabulation shows that of 6,428 blossoms covered, on 56 varieties, representing all classes of plums, only five produced fruits, and from the experiments he draws the conclusion that "For all practical purposes, all classes and varieties of native plums may be regarded as absolutely self-sterile." It is possible that these results might vary with different seasons and in different localities, but making due allowance for possible variations, the results are startling enough to warrant the attention of plum growers everywhere. The cause of this sterility appears to lie largely in the inefficiency of the pollen of the flowers of a plant upon the stigmas of the flowers of the same plant. It lies in a condition known to exist among many wild as well as cultivated plants. One of nature's provisions for securing cross-fertilization, and the plants come under the recognized Knight's Law that "Nature intended that a sexual intercourse should take place between neighboring plants of the same species."

Self-sterility may also be due in some degree to imperfect pistils, the cause for which must be sought in some physiological weakness of the tree, such as might be brought about by the work of insects or disease, or from a feeble condition following the production of a phenomenally heavy crop of fruit. Or it may be due to unfavorable weather conditions prevailing at blooming time.

Recognizing, then, the existence of self-sterility among plums, the aim should be to so associate the varieties that one may supply pollen for the other. No data is at hand to warrant any definite statement as to what varieties are especially adapted to the fertilization of certain other varieties, but it is perfectly plain that to be of use to each other the varieties must bloom at the same time.

The varieties now available from which to choose show a rather wide range in blooming period; some bloom together, some finish before others begin and some overlap. All are much influenced by the weather at the time, and this may vary greatly in different years, not only in the appearance of the first flowers, but in the length of the blooming period. While irregularities may occur from one season to another, it is probable that the relative periods of the different varieties will remain much the same. For the convenience of those who may be interested, and also as a stim-



ulus to further observations, we here reproduce a graphic tabulation of blossoming periods as given by Mr. J. W. Kerr of Denton, Maryland, in his trade catalogue. The same table is also given by Professor Waugh in the tenth report of the Vermont station. The latitude of Denton is very nearly that of Colorado Springs, but differences in altitude and climate make a considerable difference in the season of growth. The varieties are arranged in the table in the order of blossoming and it serves to show those blooming together as well as the earliest and latest bloomers. It will be observed that the classes to which the varieties are referred embrace three not given in our list; Nigra, Wayland, and Watsoni. The first is separated from *Prunus Americana* and recognizes in the northeastern plums the variety nigra of that species. The Wayland group is separated from the Miner group, with which it has close affinities. The Watsoni group are varieties of *Prunus Watsoni*, a sand plum ranging from Nebraska to Arkansas, and in the cultivated forms closely resembling the Chicasaw varieties with which they are usually classed.



## PLUM BLOSSOM CHART.

Showing average plum blossoming seasons in the latitude of Denton, Md.

From J.W.Kerr's catalogue. Fall of 1897.

| Variety          | Class      | April | 9 | 14 | 19 | 24 | 29 |
|------------------|------------|-------|---|----|----|----|----|
| Burbank          | Japanese   |       |   |    |    |    |    |
| Abundance        | do         |       |   |    |    |    |    |
| Satsuma          | do         |       |   |    |    |    |    |
| DeCaradeuc       | Hybrid     |       |   |    |    |    |    |
| Georgeson        | Japanese   |       |   |    |    |    |    |
| Engre            | do         |       |   |    |    |    |    |
| Marianna         | Hybrid     |       |   |    |    |    |    |
| Ogoh             | Japanese   |       |   |    |    |    |    |
| Chase            | do         |       |   |    |    |    |    |
| Brill            | Hybrid?    |       |   |    |    |    |    |
| Chabot           | Japanese   |       |   |    |    |    |    |
| Kelsey           | do         |       |   |    |    |    |    |
| Ogeechee         | Chicasaw   |       |   |    |    |    |    |
| Shiro Sumomo     | Japanese   |       |   |    |    |    |    |
| Strawberry       | Watsoni    |       |   |    |    |    |    |
| Uchi Beni        | Japanese   |       |   |    |    |    |    |
| Maru             | do         |       |   |    |    |    |    |
| Wazata           | Nigra      |       |   |    |    |    |    |
| Yosebe           | Japanese   |       |   |    |    |    |    |
| Caddo Chief      | Chicasaw   |       |   |    |    |    |    |
| Early Red        | do         |       |   |    |    |    |    |
| Emerson          | do         |       |   |    |    |    |    |
| Itaska           | Nigra      |       |   |    |    |    |    |
| Kerr             | Japanese   |       |   |    |    |    |    |
| Munson           | Chicasaw   |       |   |    |    |    |    |
| Beaty            | do         |       |   |    |    |    |    |
| Clark            | Wild Goose |       |   |    |    |    |    |
| Clifford         | do         |       |   |    |    |    |    |
| Colletta         | Chicasaw   |       |   |    |    |    |    |
| Deep Creek       | Americana  |       |   |    |    |    |    |
| Drouth King      | Wild Goose |       |   |    |    |    |    |
| El Paso          | Chicasaw   |       |   |    |    |    |    |
| Hattie           | Myrobalan  |       |   |    |    |    |    |
| Yellow Sweet     | Americana  |       |   |    |    |    |    |
| Arkansas Lombard | Chicasaw   |       |   |    |    |    |    |
| Cheney           | Nigra      |       |   |    |    |    |    |
| De Soto          | Americana  |       |   |    |    |    |    |
| Harrison         | do         |       |   |    |    |    |    |
| Heaton           | do         |       |   |    |    |    |    |
| Hiawatha         | do         |       |   |    |    |    |    |
| Hogg's No.2      | Hybrid     |       |   |    |    |    |    |
| Hughes           | Chicasaw   |       |   |    |    |    |    |
| Jefferson        | Domestica  |       |   |    |    |    |    |
| Lombard          | do         |       |   |    |    |    |    |

## Plum Blossom Chart. continued.

| Variety                | Class      | April 9 | 14 | 19 | 24 | 29 |
|------------------------|------------|---------|----|----|----|----|
| Milton                 | Wild Goose |         |    |    |    |    |
| Newman                 | Chicasaw   |         |    |    |    |    |
| Ocheeda                | Americana  |         |    |    |    |    |
| Richland               | Domestica  |         |    |    |    |    |
| Rollingstone           | Americana  |         |    |    |    |    |
| Spaulding              | Domestica  |         |    |    |    |    |
| Wilder                 | Miner      |         |    |    |    |    |
| Wild Goose             | Wild Goose |         |    |    |    |    |
| Willard                | Japanese   |         |    |    |    |    |
| Yellow Panhandle       | Watsoni    |         |    |    |    |    |
| African                | Chicasaw   |         |    |    |    |    |
| Cherokee               | Americana  |         |    |    |    |    |
| Freeman's Favorite     | Wild Goose |         |    |    |    |    |
| Gaylord                | Americana  |         |    |    |    |    |
| Hilltop                | do         |         |    |    |    |    |
| Louisa                 | do         |         |    |    |    |    |
| Miner                  | Miner      |         |    |    |    |    |
| Minnetonka             | Americana  |         |    |    |    |    |
| Ohio Prolific          | Wild Goose |         |    |    |    |    |
| Osage                  | do         |         |    |    |    |    |
| Smiley                 | do         |         |    |    |    |    |
| Speer                  | Americana  |         |    |    |    |    |
| Texas Belle            | Wild Goose |         |    |    |    |    |
| Van Buren              | Americana  |         |    |    |    |    |
| Whitaker               | Wild Goose |         |    |    |    |    |
| Yellow Transparent     | Chicasaw   |         |    |    |    |    |
| Comfort                | Americana  |         |    |    |    |    |
| Cottrell               | do         |         |    |    |    |    |
| Cumberland             | Wayland    |         |    |    |    |    |
| Kickapoo               | Americana  |         |    |    |    |    |
| Lone Star              | Chicasaw   |         |    |    |    |    |
| Lord's Seedling        | Americana  |         |    |    |    |    |
| Rockford               | do         |         |    |    |    |    |
| Roulette               | Wild Goose |         |    |    |    |    |
| Schley                 | do         |         |    |    |    |    |
| Champion               | Americana  |         |    |    |    |    |
| Chas. Downing          | Wild Goose |         |    |    |    |    |
| Clara                  | Americana? |         |    |    |    |    |
| Cluck                  | Chicasaw   |         |    |    |    |    |
| Crescent City          | Miner      |         |    |    |    |    |
| Columbia               | Wayland    |         |    |    |    |    |
| Dr. Tyler's Sugar Drop | Domestica  |         |    |    |    |    |
| Gordon                 | Americana  |         |    |    |    |    |
| Hammer                 | do         |         |    |    |    |    |
| Hawkeye                | do         |         |    |    |    |    |
| Idall                  | Miner      |         |    |    |    |    |
| Indian Chief           | Wild Goose |         |    |    |    |    |





| Plum blossom chart. continued. |            | April | 9 | 14 | 19 | 24 | 29 |
|--------------------------------|------------|-------|---|----|----|----|----|
| Variety                        | Class      |       |   |    |    |    |    |
| Williams' No. 17               | Americana  |       |   |    |    |    |    |
| Wolf                           | do         |       |   |    |    |    |    |
| Forest Garden                  | do         |       |   |    |    |    |    |
| Red Panhandle                  | Watsoni    |       |   |    |    |    |    |
| Smith                          | Americana  |       |   |    |    |    |    |
| Utah Hybrid                    | Hybrid     |       |   |    |    |    |    |
| Wayland                        | Wayland    |       |   |    |    |    |    |
| World-beater                   | do         |       |   |    |    |    |    |
| Wyant                          | Americana  |       |   |    |    |    |    |
| American Eagle                 | do         |       |   |    |    |    |    |
| Garfield                       | Wayland    |       |   |    |    |    |    |
| Illinois Ironclad              | Americana  |       |   |    |    |    |    |
| Irene                          | do         |       |   |    |    |    |    |
| Kanawha                        | Wayland    |       |   |    |    |    |    |
| Leptune                        | do         |       |   |    |    |    |    |
| Marion                         | Americana  |       |   |    |    |    |    |
| Blackhawk                      | do         |       |   |    |    |    |    |
| Rachel                         | Miner      |       |   |    |    |    |    |
| Reed                           | Wayland    |       |   |    |    |    |    |
| Choptank                       | Wild Goose |       |   |    |    |    |    |
| Esther                         | Miner      |       |   |    |    |    |    |
| Galena                         | Americana  |       |   |    |    |    |    |
| Golden Beauty                  | Wayland    |       |   |    |    |    |    |
| Heideman's 88                  | Americana  |       |   |    |    |    |    |
| Heideman's Black               | Besseyi    |       |   |    |    |    |    |
| Heideman's Red                 | do         |       |   |    |    |    |    |
| Heideman's Yell                | do         |       |   |    |    |    |    |
| Newton Egg                     | Americana  |       |   |    |    |    |    |
| Pendent                        | Wild Goose |       |   |    |    |    |    |
| Reche                          | Americana  |       |   |    |    |    |    |
| William's No. 0                | do         |       |   |    |    |    |    |
| Winnebago                      | do         |       |   |    |    |    |    |
| Wood                           | do         |       |   |    |    |    |    |
| Prunus maritima                | Maritima   |       |   |    |    |    |    |
| Holt                           | Americana  |       |   |    |    |    |    |
| Joe Hooker                     | do         |       |   |    |    |    |    |
| Peffer's Premium               | do         |       |   |    |    |    |    |
| Smith's Red                    | do         |       |   |    |    |    |    |

The following table arranged on the same plan as the preceeding shows the blossoming period of 56 varieties as compiled from observations in the station orchard last spring. Five of the varieties are represented by old trees of uncertain age, and of whose early history we have no record. They are probably from 12 to 15 years old.

The representatives of five others are young trees planted in 1897 and blooming for the first time. The remainder were planted in 1894. The flowering period of Joe Hooker was probably delayed, and later prolonged by the trees having been killed back somewhat during the preceeding winter. The flowering period is here computed from the time the first flowers opened until the petals had in great part fallen.

For the year 1898.

[illegible]



The two striking differences between the Maryland and Colorado tables are in the commencement of blooming, and in the length of the periods. Variations in climate would lead us to expect differences in the commencement of blooming. This difference here appears as 17 days, and it is probable that variations in seasons might either increase or diminish this. The variation in length of period is extreme. The shortest period recorded in the Maryland table is two days. Our shortest is 12 days. While the longest periods are 7 days in Maryland, and 31 days in Colorado. The great length of the periods observed here may in part be accounted for by the weather conditions prevailing at the time. It will be observed that 11 varieties began blooming on April 30, and that 9 varieties began on May 7, none opening in the interval. This is directly attributable to a storm which prevailed between these dates.

Rain began falling on April 30. On the night of May 2 wet snow accumulated to the depth of 3 inches. This covered the trees and clung to the branches for several days. It was continuously cloudy to the evening of May 5, and while it did not freeze during this period the temperature was sufficiently low to effectually check all vegetation. On examination after the storm it was found that considerable injury had been done. The *Americana* varieties that began opening the flowers before the storm, had most of the pistils in the open, and nearly open flowers killed. Kampeska showed less injury than any other variety of the class. On Minnetonka, Speer, Ocheeda and some others, it was difficult to find an uninjured pistil in open flowers or much advanced buds; most of them were black and shriveled. Coe's Golden Drop among *domestica* varieties had the pistils killed in all open flowers, and also in all advanced buds. Russian No. 2, although having no open flowers, had started the buds to some extent and nearly all were killed. Varieties that were at the time quite dormant suffered no apparent injury.

The storm had the direct effect of delaying the appearance of bloom on most varieties for at least seven days. Whether it effected the blooming period or not is matter of conjecture, but it seems probable that the long period of low temperature may have influenced the vitality of the buds in such way as to prolong the blooming season. The tables are suggestive, and the questions which arise from studying them can only be answered from the data of a number of seasons. Similar tables representing the different districts of the state, and covering other orchard fruits would be

helpful to the planter, and would become more valuable as the number of years over which observations extend, increased.

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#### TO WHAT DEGREE ARE PLUMS SELF-FERTILE.

The following tests to determine self-fertility were undertaken last spring, the work being in charge of my assistant, Mr. J. H. Cowan, who was assisted by one of our students. The preliminary work of covering the flowers was performed on April 30th, with the exception that the flower clusters on one variety, Missouri Apricot, were covered May 7. Grocer's paper bags were used and securely tied. Such flowers as were open, or partially open, were removed before covering, and are not counted. Approximately one half of the clusters were hand-pollinated, the other half being left to themselves. The hand-pollinated set embraced 43 clusters, containing 629 flowers and represented 40 varieties. The stigmas of all flowers were dusted with pollen, either from the same flower, or from other flowers of the same cluster. This work was performed on the dates as tabulated, May 14-18 inclusive. The pistils were at this time in good condition, the stigmas appreciably viscid. The pollen was also in good condition, and the stigmas were copiously covered.

The examination June 6 showed 113 apparently well formed fruits, and 105 imperfect fruits, those that showed some development of the ovary, but did not appear to be well fertilized. In other words it appeared on June 6 that 17.94 per cent. of the flowers had produced good fruits, and 16.69 per cent. had set imperfect fruits. At the final examination June 23 there remained 6 fruits representing a fraction less than 1 per cent. of the flowers pollinated.

In the following tabulation the number of flowers treated is given for each variety, together with the number of fruits formed, and also the estimated stand of fruit on the trees.

## SELF-POLLINATION OF PLUMS. SPRING OF 1898.

## Tabulation of Hand-pollinated Set.

|                        | When<br>pollinated. | No. of<br>flowers. | Fruits<br>Good. | Jun. 6<br>Imp. | Fruits<br>June 23. | Stand of fruit<br>estimated. |
|------------------------|---------------------|--------------------|-----------------|----------------|--------------------|------------------------------|
| American Eagle.....    | May 14              | 16                 | 2               | 2              | 1                  | light                        |
| Apricot.....           | " 17                | 7                  | 0               | 1              | 0                  | medium                       |
| Cheney.....            | " 14                | 8                  | 0               | 5              | 0                  | very light                   |
| Colorado Queen.....    | " 14                | 13                 | 5               | 2              | 1                  | medium                       |
| Comfort.....           | " 14                | 4                  | 0               | 0              | 0                  | very light                   |
| Cottrell.....          | " 18                | 18                 | 10              | 2              | 0                  | medium                       |
| Deep Creek.....        | " 14                | 23                 | 0               | 1              | 0                  | medium                       |
| Deep Creek.....        | " 17                | 19                 | 0               | 0              | 0                  | medium                       |
| Forest Rose.....       | " 14                | 17                 | 0               | 3              | 0                  | medium                       |
| Hammer.....            | " 18                | 8                  | 4               | 0              | 0                  | none                         |
| Harrison.....          | " 14                | 9                  | 0               | 6              | 0                  | heavy                        |
| Hawkeye.....           | " 14                | 13                 | 4               | 1              | 0                  | medium                       |
| Hilltop.....           | " 14                | 17                 | 0               | 2              | 0                  | very light                   |
| Ida.....               | " 14                | 14                 | 4               | 3              | 0                  | very light                   |
| Idall.....             | " 14                | 12                 | 0               | 8              | 0                  | very light                   |
| Illinois Ironclad..... | " 17                | 23                 | 0               | 0              | 0                  | light                        |
| Joe Hooker.....        | " 14                | 10                 | 0               | 1              | 0                  | very light                   |
| Kampeska.....          | " 14                | 15                 | 0               | 4              | 0                  | medium                       |
| Kickapoo.....          | " 17                | 8                  | 5               | 0              | 0                  | medium                       |
| Kopp.....              | " 14                | 19                 | 0               | 8              | 0                  | medium                       |
| Le Duc.....            | " 17                | 14                 | 5               | 4              | 0                  | very light                   |
| Leonard.....           | " 18                | 22                 | 8               | 0              | 0                  | very light                   |
| Little Blue Damson..   | " 17                | 13                 | 2               | 1              | 0                  | medium                       |
| Maryland.....          | " 14                | 19                 | 0               | 0              | 0                  | very light                   |
| Miner.....             | " 18                | 22                 | 8               | 0              | 0                  | very light                   |
| Minnetonka.....        | " 18                | 13                 | 1               | 2              | 1                  | very light                   |
| Missouri Apricot.....  | " 14                | 10                 | 2               | 3              | 1                  | light                        |
| Moon.....              | " 17                | 27                 | 9               | 7              | 0                  | light                        |
| Ocheeda.....           | " 17                | 15                 | 4               | 6              | 0                  | medium                       |
| Peffer's Premium.....  | " 17                | 12                 | 2               | 6              | 0                  | medium                       |
| Prairie Flower.....    | " 18                | 13                 | 8               | 0              | 0                  | very light                   |
| Purple Yosemite.....   | " 14                | 10                 | 6               | 1              | 0                  | heavy                        |
| Quaker.....            | " 18                | 20                 | 1               | 2              | 0                  | none                         |
| Rockford.....          | " 17                | 4                  | 0               | 0              | 0                  | very light                   |
| Speer.....             | " 17                | 15                 | 4               | 5              | 0                  | very light                   |
| Van Buren.....         | " 17                | 34                 | 7               | 9              | 2                  | medium                       |
| Weaver.....            | " 14                | 7                  | 0               | 0              | 0                  | very light                   |
| Weaver.....            | " 14                | 6                  | 2               | 1              | 0                  | very light                   |
| Winnebago.....         | " 14                | 26                 | 2               | 3              | 0                  | heavy                        |
| Wolf (young tree)....  | " 14                | 20                 | 0               | 4              | 0                  | heavy                        |
| Wyant.....             | " 14                | 26                 | 8               | 2              | 0                  | very light                   |
| Yellow Sweet.....      | " 14                | 8                  | 0               | 0              | 0                  | very light                   |
|                        |                     | 629                | 113             | 105            | 6                  |                              |

The self-pollinated set embraced 48 clusters containing 699 flowers and represented 41 varieties. At the time the pollen was applied to the flowers of the other set, these clusters were examined and such flowers as then had dead pistils were removed, otherwise they were not disturbed until the count of June 6 was made.



## SELF POLLINATION OF PLUMS. SPRING OF 1898.

## Tabulation of Set Not Hand-pollinated.

|                         | Number of<br>flowers. | Fruits June 6 |            | Fruits<br>June 23. | Stand of fruit<br>estimated, |
|-------------------------|-----------------------|---------------|------------|--------------------|------------------------------|
|                         |                       | Good.         | Imperfect. |                    |                              |
| American Eagle .....    | 10                    | 2             | 2          | 0                  | light                        |
| Apricot .....           | 16                    | 0             | 0          | 0                  | medium                       |
| Cheney .....            | 8                     | 0             | 0          | 0                  | very light                   |
| Colorado Queen .....    | 19                    | 3             | 8          | 0                  | medium                       |
| Comfort .....           | 2                     | 0             | 2          | 0                  | light                        |
| Cottrell .....          | 19                    | 4             | 4          | 0                  | medium                       |
| Deep Creek .....        | 11                    | 0             | 2          | 0                  | medium                       |
| Deep Creek .....        | 12                    | 0             | 0          | 0                  | medium                       |
| Forest Rose .....       | 14                    | 0             | 2          | 0                  | medium                       |
| Hammer .....            | 8                     | 2             | 1          | 0                  | none                         |
| Harrison .....          | 11                    | 0             | 0          | 0                  | heavy                        |
| Hawkeye .....           | 11                    | 4             | 1          | 0                  | medium                       |
| Hilltop .....           | 11                    | 0             | 0          | 0                  | very light                   |
| Ida .....               | 14                    | 1             | 4          | 0                  | very light                   |
| Idall .....             | 15                    | 4             | 4          | 0                  | very light                   |
| Illinois Ironclad ..... | 22                    | 0             | 0          | 0                  | light                        |
| Joe Hooker .....        | 15                    | 5             | 1          | 0                  | very light                   |
| Kampeska .....          | 14                    | 0             | 2          | 0                  | medium                       |
| Kickapoo .....          | 10                    | 6             | 2          | 0                  | medium                       |
| Kopp .....              | 25                    | 0             | 8          | 0                  | medium                       |
| Le Duc .....            | 9                     | 3             | 5          | 0                  | very light                   |
| Leonard .....           | 16                    | 0             | 5          | 0                  | medium                       |
| Little Blue Damson ...  | 15                    | 7             | 0          | 4                  | medium                       |
| Maryland .....          | 20                    | 0             | 0          | 0                  | very light                   |
| Miner .....             | 21                    | 8             | 0          | 0                  | very light                   |
| Minnetonka .....        | 10                    | 0             | 2          | 0                  | very light                   |
| Missouri Apricot .....  | 14                    | 0             | 9          | 0                  | light                        |
| Moon .....              | 28                    | 11            | 8          | 0                  | light                        |
| Ochæda .....            | 18                    | 6             | 2          | 0                  | medium                       |
| Peffer's Premium .....  | 17                    | 4             | 10         | 0                  | medium                       |
| Pennock's Hybrid .....  | 37                    | 0             | 3          | 0                  | light                        |
| Prairie Flower .....    | 13                    | 8             | 0          | 0                  | very light                   |
| Purple Yosemite .....   | 15                    | 9             | 6          | 1                  | heavy                        |
| Quaker .....            | 18                    | 1             | 1          | 0                  | none                         |
| Rockford .....          | 2                     | 1             | 0          | 1                  | very light                   |
| Speer .....             | 10                    | 3             | 4          | 0                  | very light                   |
| Van Buren .....         | 90                    | 15            | 18         | 0                  | medium                       |
| Weaver .....            | 9                     | 1             | 0          | 0                  | very light                   |
| Weaver .....            | 7                     | 0             | 0          | 0                  | very light                   |
| Winnebago .....         | 20                    | 0             | 4          | 0                  | heavy                        |
| Wolf (young tree) ....  | 24                    | 6             | 6          | 1                  | heavy                        |
| Wyant .....             | 15                    | 9             | 3          | 0                  | very light                   |
| Yellow Sweet .....      | 4                     | 0             | 0          | 0                  | very light                   |
|                         | 699                   | 123           | 129        | 7                  |                              |

It appears from the table that on June 6 there were 123 well formed fruits and 129 imperfect fruits. Or of 699 flowers covered, 14.73 per cent. set good fruits and 15.59 per cent. set imperfect fruits. On June 23 the number of fruits remaining was 7 which represents practically 1 per cent. of the flowers covered.

The number of fruits produced by the hand-pollinated flowers was 6.

In final results, then, there is a remarkably close agree-

ment between the two sets. The natural conclusion is that the infertility did not lie in the failure of the stigmas to receive pollen, but must be looked for either in an inherent antipathy which the plant has for its own pollen or in some outside influences. One factor comes in here which makes the test unsatisfactory, and prevents drawing definite conclusions as to the cause of the infertility, and that is the extent of the "June drop" from all parts of the trees. This was so great that even the trees that set full, matured but a light crop. The same influences acting upon the covered flowers would account, in part at least, for the results recorded. Further discussion of the cause is reserved until additional observations suggested by the work this year can be made.

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## INSECTS AND DISEASES.

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### INSECTS.

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The insects commonly injurious to the plum, such as the Plum Gouger, Curculio and Plum Aphis are treated in bulletin No. 47 by Prof. Gillette, and for information concerning them the reader is referred to that bulletin.

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### FUNGUS DISEASES.

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There are several parasitic fungi reported from different parts of the country as injurious to the plum. At least four of these are present in Colorado, although only two have thus far worked to an injurious extent upon the cultivated plums. The fungus at present doing greatest injury, and having widest distribution, is the Leaf-spot or Shot-hole fungus (*Cylindrosporium Padi Karst*). It has been present in the station orchard for four seasons, but has been controlled by spraying so that no serious injury has resulted from it.

The disease makes its appearance early in the summer or about the time the leaves reach full size. Small circular spots of a red or purplish color are first seen; these enlarge somewhat, becoming an eighth of an inch in diameter. As

the fungus matures the spots become dark brown, shading to light brown at the center. The effected tissue shrivels, and finally drops out, leaving circular holes. Frequently several spots may run together so that the holes left in the leaf are irregular in form. Under conditions favorable to the fungus the spots become so numerous as to destroy the leaves attacked, and thus check the growth of the tree, and prevent the development of fruit. If stocks in nursery are attacked the bark tightens and the stocks cannot be budded. The injury to orchard trees by this disease is in direct proportion to the percentage of leaves destroyed, but no matter how slight the attack it should receive attention. The tree is entirely dependent upon the leaves for the elaboration of its food, and any injury to them that interferes with the fulfillment of this important office, checks growth and injures vitality.

Various remedies have been tried and of these the Bordeaux mixture gives the most general satisfaction. In our practice with this remedy we have made two applications; the first as soon as the leaves are developed, and a second about three weeks later. In some seasons a third and possibly a fourth application may be necessary, as the development and spread of the fungus is in a measure dependent upon weather conditions. The appearance of leaves attacked by this fungus is shown in Plate III.

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#### POWDERY MILDEW OF THE PLUM AND CHERRY.

(*Podosphæra oxyacanthæ* (DC.) DBY.)

This disease has not appeared in the station orchard, but has been reported to us from two counties of the state as injurious to both plum and cherry trees. The fungus works entirely on the surface of the leaves, drawing its nourishment from the cells by means of minute suckers called haustoria. Badly effected leaves appear as if dusted with a white powder and this suggested the common name. Being on the surface the fungus is easily reached by any of the fungicides in common use. Finely powdered sulphur, which has been successfully used in combatting the closely related Powdery Mildew of the Grape, would probably be equally effective in destroying this parasite. The fungus does not usually appear until late in summer; our specimens were received the last week in August.



**BLACK KNOT.** (*Plowrightia morbosa*. (Schw.) Sacc.)

The fungus causing Black Knot has proved destructive to plums and cherries in many of the eastern states. It has not, so far as my information goes, attacked cultivated plums in Colorado, but from its presence as a common disease of the wild plums of the foothills, it seems likely that it may at any time appear in orchards.

Black Knot has been known as a disease of plums for a long time, but the cause was for many years a mystery. The larvæ of insects being commonly found in old knots, led many to believe that the trouble was due to them, but entomologists proved that the larvæ found were only using the abnormally developed tissue as food and had nothing to do with its production. The fungus was named as early as 1821, but discussion regarding the true cause continued until Dr. Farlow,\* of Cambridge, worked out the life-history of the fungus and established beyond controversy that it was the cause of the trouble.

The presence of the disease is first seen in swellings on twigs; these are due to an abnormal growth induced by some irritative action of the fungus threads. As development proceeds the bark is ruptured, the exposed inner surface becomes covered with spore bearing threads, and assumes a greenish-brown color. These spores are carried by winds and insects and serve to infect other branches or trees. The knot continues to enlarge, becomes hard and changes to a brown and finally black color. Later in the fall cavities form in the tissue of the knot and in these are produced a second form of spores which may escape in spring to further disseminate the fungus. Two other spore forms have been found in connection with the fungus, but further mention of them is not necessary here. The threads of the fungus are perennial within the tissues of the plant, and when once started, growth will continue until the tree dies. While spraying at the proper time may be of use in preventing spreading to other trees, the only effective remedy for trees attacked, is to cut and burn the knots as soon as discovered. One of the characteristic knots is shown in Fig. 1, Plate 4.

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\* Bulletin Bussey Institution Part V pp. 440-453 (1876).

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**PLUM POCKETS.** (*Exoascus Pruni* Eckl.)

This disease is quite common on the wild *Prunus Americana* of the foothills, but no case of attack upon cultivated varieties has come to my notice. The effects produced by the growth of this fungus are perfectly characteristic. Not long after the fall of the blossoms the young plums begin to enlarge rapidly; they become spongy or bladdery, and may vary in size from one-half inch to an inch and a half in diameter. In color they are pale green or yellowish. By the middle of June they shrivel somewhat, becoming wrinkled, and finally drop. Sometimes only a portion of the fruits on a tree are effected and again no normal fruits can be found. The fungus sometimes attacks the leaves and young twigs, but more commonly the fruit only is effected. From observations on wild plums it appears that trees once infected continue to produce pockets each year, and it is doubtful if these trees can be cured; but spreading to other trees can be prevented by gathering and destroying the pockets before the spores are discharged. Where the disease attacks cultivated plums it seems to be quite local and does not spread rapidly. It is never epidemic and there seems to be little danger of serious injury from it. Plum pockets as they occur on the wild plum are illustrated in Fig. 2, Plate 4, which was photographed from a dry specimen.

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**A BLIGHT DISEASE.**

Late in the summer of 1897 twelve trees in the orchard were attacked by a blight, the nature of which is obscure. The leaves began turning brown at the edges; this spread, involving the whole leaf surface and the trees died. Examination failed to reveal the presence of fungi, and it seems most probable, from the appearance and development of the disease, that its cause must be sought in some bacterium. The disease, while possessing the same general nature as pear blight, is certainly distinct from it. The trees attacked were all old and in bearing. No young trees suffered, and there was no reappearance of the disease this season.

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**VARIETIES.**

The following notes on varieties are based almost wholly upon observations made in the station orchard.



This orchard, as originally set, contained the following varieties:

|                    |                     |
|--------------------|---------------------|
| Coe's Golden Drop. | Prairie Flower.     |
| Wolf.              | Marion.             |
| Russian No. 2.     | Forest Garden.      |
| Miner.             | Little Blue Damson. |

We have no record of the planting, and do not know the year, or the original number of trees, or the source from which they were obtained. The original planting is now represented by 1, Coe's Golden Drop; 29, Wolf; 1, Russian No. 2; 10, Miner, and 9, Prairie Flower.

The following additions have been made: In 1894, 57 varieties; in 1895, 10 varieties; in 1896, 1 variety; in 1897, 62 varieties; in 1898, 31 varieties. The total number of varieties planted for trial is 169. Seventeen varieties have been lost through winter-killing, so that there are now living representatives of 152 varieties. Some of these give no promise of value and will be discarded. The number that have proved suited to our conditions is not large, and nearly all of them are of the American group. Detailed descriptions are given only of those varieties that are fruited. A few others are briefly mentioned.

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#### AMERICAN EAGLE. (*Prunus Americana*.)

Represented by nine trees planted in the spring of 1894. Trees well formed, spreading in habit, of moderate vigor. Leaves large; young stems and petioles densely puberulent. Bore heavily in 1897, followed by a light crop in 1898. Fruit large, round-oblong, dark red or mottled with small yellow spots; stem of medium length; skin thick; flesh firm, reddish yellow, of excellent quality. Stone rather small for the size of the fruit, cling, rounded at apex, prolonged into a sharp point at stem end, strongly convex on the sides, margin sharp, but not otherwise prominent. Ripe September 20.

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#### APRICOT. (*Prunus Americana*.)

Planted in 1894. Of bushy habit, forming a close, compact head. Leaves large, broad, sharply serrate, stalks pale red, pubescent. Fruit medium in size, round-oblong, color red, where shaded mottled red on yellow ground, bloom slight; suture inconspicuous, skin thick; flesh reddish-yellow, quite firm, juicy, sweet and of good flavor when fully ripe. Stone cling, rather large, flat, moderately pointed at both ends, no prominent margin, roughish. Ripe September 4.



**BOTAN. JAPANESE GROUP.** (*Prunus triflora.*)

Our trees were planted in 1897 and have not yet had sufficient test as to hardiness. They have made a vigorous growth and are now well set with fruit buds. Leaves of medium size, glossy, light green, sharp-pointed at both ends; stalks short and stout.

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**BURBANK. JAPANESE GROUP.** (*Prunus triflora.*)

Trees planted in 1897 bore a few fruits this season. Habit of growth upright, very vigorous. Leaves of medium size, broadly lanceolate, short acuminate, stalk short and stout. Fruit large, peach-like in shape; color deep red, on yellow ground, which appears in small spots; flesh firm, deep yellow; suture evident; stone small, semi-cling. Ripe September 12.

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**CHAMPION.** (*Prunus Americana.*)

Trees planted in 1894 have made a vigorous spreading growth, smooth, less thorny than most members of the group. Leaves large, light glossy green, strongly recurved, stalks red, short, somewhat pubescent. Not yet fruited.

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**CHENEY.** (*Prunus Americana.*)

Planted in 1894. Very vigorous in growth and upright in habit, producing no virgate drooping branches; quite thorny; leaves obovate, acuminate, three to five inches long, veins prominent, pubescent below, light green, leathery in texture, stalks stout, about an inch long; fruit large, somewhat oblique, pointed or rounded at apex; stem short, stout, set in a large cavity, suture evident; color dull red, mottled on a greenish-yellow ground; stone cling; skin thick, flesh firm, sweet, of good flavor. Ripe September 4. One of the most promising of the Americana varieties. Fruit fig. 1, plate V; tree, plate VIII.

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**CHOPTANK. WILD GOOSE GROUP.** (*Prunus hortulana.*)

Trees planted in 1894 have made a vigorous growth each year, and have regularly killed back nearly to the ground each winter. Evidently too tender for this locality.

**CLARK. WILD GOOSE GROUP.** (*Prunus hortulana*.)

Trees well formed and of moderately vigorous growth. Kills back at the tips each year. Leaves of medium size, rather broad for the species; fruit of medium size, nearly spherical, but somewhat irregular; color red in the sun, shading to light red on green ground in the shade; suture distinct; flesh firm, orange-red, very acid; stone cling. Ripe Aug. 30. The quality of the fruit does not commend the variety.

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**CLINTON. MINER GROUP.** (*Prunus hortulana* var. *Mineri*.)

Trees planted in 1894. A vigorous grower, but has killed back repeatedly; worthless here,

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**COE'S GOLDEN DROP.** (*Prunus domestica*.)

This well-known English variety is perfectly hardy in tree, but the fruit buds are yearly killed to such an extent that it is not at all productive. Trees are upright in habit and of slow growth. Leaves of medium size, dull dark green, obtusely crenate, stalks glandular, pubescent, as are also the lower surfaces of the leaves; young wood dark purplish-red, glabrous. Fruit large, roundish-oblong, projected into a slight neck, and indented at insertion of stem, suture deep, sides somewhat unequal; color pale yellow or greenish; flesh firm, of excellent quality; stone free, nearly straight on one edge, curved on the other, margin irregular, sharp, rough. Ripe September 20.

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**COLORADO QUEEN.** (*Prunus Americana*.)

Trees planted in 1894 are well formed and of vigorous growth, much inclined to the production of long drooping or pendulous branches. Leaves of medium size, broad, sharply serrate, light green, stalks slender, young wood light colored, glabrous. Fruit below medium in size, spherical, slightly indented at lower end; color dark purplish-red over yellow ground which shows as small dots; suture hardly apparent; stem long, rather stout; skin thin, flesh juicy, sub-acid, of fair quality; stone circular, convex. Ripe September 4.

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**COMFORT.** (*Prunus Americana.*)

Of slow growth and straggling habit, very thorny, producing many drooping branches; leaves of medium size, ovate-lanceolate, sharply and irregularly serrate, stipules large and rather broad, soon falling. Hardy. Although planted in 1894 the trees have not yet fruited.

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**COTTRELL.** (*Prunus Americana.*)

Planted in 1894. Trees vigorous, but irregular in habit, hardy; young wood brownish-red, glabrous; leaves above average size, dull light green, broad, coarsely and irregularly serrate; stalks glandular, rather short and stout, red, pubescent. Fruit medium to large, round-oblong, color red, nearly uniform, on lemon-yellow ground, and covered with a thin rosy bloom; skin thin, flesh firm, of superior flavor; stone semi-cling, large, smooth, elliptical with a prominent rounded margin, convex portion relatively small; stalk long, slender. Ripe September 14. Quality and productiveness place this among the desirable varieties.

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**DEEP CREEK.** (*Prunus Americana.*)

Our trees were planted in 1894 and 1895. They are inclined to be irregular in habit and are of slow growth as compared with Weaver or Cheney. They are very thorny and in general appearance resemble wild trees; young wood glabrous. Leaves large, oblong-lanceolate, coarsely and bluntly serrate, stalks red, slightly pubescent, rarely glandular. Fruit small to medium, roundish or slightly oblong; suture apparent, or in some fruits inconspicuous; color uniformly deep red when fully ripe, bloom abundant; stem of medium length, slender; skin thick; flesh firm, juicy, sweet when ripe; stone semi-cling, oblong, sides strongly convex, pointed, smooth. Ripe August 30. Fairly productive. Trees planted in 1894 bore a light crop in 1896, a heavy crop in 1897 and a light crop in 1898. Fruit fig. 2, plate V; tree, plate IX.

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**FOREST GARDEN.** (*Prunus Americana.*)

Tree typical of the class; leaves of medium size, light green, sharply serrate, the teeth overlapping, stalks reddish, nearly glabrous, glandless. Fruit medium in size, round;



color dark purple-red; stem long, slender, skin thick; flesh moderately firm, of sub-acid flavor; stone semi-cling, rounded at lower end, sides convex, prolonged into a flattened point at upper end, roughish. Ripe September 16. Tree a heavy bearer.

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**FOREST ROSE. MINER GROUP.** (*Prunus hortulana* var. *Mineri*.)

Represented by two station-grown trees. They were grafted in the spring of 1894, one on Myrobalan stock, the other on Americana stock; grown one year in nursery and set in orchard in 1895. Both fruited in 1897. The trees are alike except that the one on Myrobalan stock is slightly larger than the other. Both are of good form and vigorous growth. Leaves medium, rather broad, dull light green, sharply serrate; stalk slender, puberulent, glands commonly wanting. Fruit medium in size, round, or somewhat oblique, dark red on yellow ground which shows as minute dots; stem long, slender; skin thin, suture obsolete, flesh firm, sweet and of fine flavor; stone cling, circular, but drawn into a point at the upper end, somewhat rough. Season medium, ripe September 4. A good and productive variety. Fruit fig. 1, plate VI; tree, plate X.

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**GARFIELD. WILD GOOSE GROUP.** (*Prunus hortulana*.)

Trees planted in 1894 have killed back so badly each winter that we may class this as too tender for this locality.

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**HAMMER.** (*Prunus Americana*)

Four trees planted in 1894 are of erect habit, but of slow growth, nearly free from thorns. Kills back at the tips to some extent and has not fruited. Leaves large, oval-oblong, doubly crenate, light green, flat, stalks glandular; young wood light-red, glabrous.

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**HARRISON. HARRISON'S PEACH.** (*Prunus Americana*.)

Trees of moderate vigor, forming round symmetrical tops; hardy. Leaves large, broad, margins loosely crinkled, very irregularly and sharply serrate; stalks stout, glandular, densely puberulent. Fruit medium to large, round-

oblong; color light red on a translucent light yellow ground, covered with a thin rosy bloom; stem long, slender, skin thick; flesh rich, juicy; stone cling, rather long pointed, convex on the sides, smooth. Season medium; ripe September 11. A promising variety.

---

**HAWKEYE.** (*Prunus Americana.*)

Trees planted in 1894 are well formed and vigorous, but not quite as large as those of Wolf, Weaver or Cheney of the same age. Leaves large, obovate, glossy green, sharply and irregularly serrate. Fruit large to very large, round, slightly flattened; color dark red shading to light red on yellow ground, which shows as conspicuous dots; bloom thin, suture apparent; stem stout, of medium length; skin thick; flesh very firm; flavor excellent, sub-acid; stone cling, very large, round oval, very flat, rough. Ripe September 18. A desirable variety. Plate XI:

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**HILLTOP.** (*Prunus Americana.*)

A vigorous variety of spreading habit. Leaves medium to large, obovate, acuminate, irregularly serrate, leathery in texture, pubescent below; stalks red, pubescent, usually glandless. Trees were planted in 1894, but have not yet fruited.

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**HOLT.** (*Prunus Americana.*)

Planted at the same time as Hilltop and resembling that variety in vigor and habit. Trees killed back slightly during the winter of 1895-6. Leaves large, acuminate, sharply and irregularly serrate, upper surface crimped, stalks glandular. Not yet fruited.

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**IDA.** (*Prunus Americana.*)

Trees planted in 1894. Very thorny, of slow irregular growth; young shoots somewhat pubescent; leaves large, broadly ovate-lanceolate, irregularly serrate, leathery in texture; stalks glandless or occasionally with a single small gland. Fruit of medium size, round oblong; suture evident; color mottled and shaded with red on yellow ground, stem of medium length, stout; skin thick, flesh pale yellow, in-

ferior in flavor; stone cling, roundish, rather flat, blunt at both ends, with no prominent margin. Season medium to late. Ripe September 18. Fairly productive.

---

**IDALL. MINER GROUP.** (*Prunus hortulana* var. *Mineri*.)

Trees planted in 1894 have passed through four winters without injury and are apparently perfectly hardy. They are vigorous and have formed symmetrical heads. Leaves large, obovate, doubly serrate, dull dark green, stalks glandular and pubescent. Not yet fruited.

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**ILLINOIS IRONCLAD.** (*Prunus Americana*.)

Planted in 1894. Growth slow. Trees much smaller than those of Wolf and Weaver of the same age. Leaves large, dark green, sharply doubly serrate, the veins pubescent below; stalks red, pubescent, glandular. Fruit of medium size, oblong, truncate at base, cavity large and deep, suture inconspicuous; stem long, stout; color red on lemon-yellow ground; stone cling, oval, flat, no prominent margin or point; flesh firm, sub-acid, of good flavor. Season medium to early; ripe September 6.

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**INDIANA RED. MINER GROUP.** (*Prunus hortulana* var. *Mineri*.)

Trees planted in 1894 have killed back every year and the variety is classed as too tender.

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**JOE HOOKER.** (*Prunus Americana*.)

Trees of moderate vigor, forming well-shaped heads, but showing a tendency to the production of long drooping shoots. Leaves rather small, ovate-oblong, stalks slender. Fruit medium to small in size, roundish-oblong; color red on yellow ground. Ripe September 11.

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**KAMPESKA.** (*Prunus Americana*.)

Trees planted in 1894. Growth stocky and slow, branches stiff. Leaves below average size, light green, obovate, sharply acuminate and very sharply serrate; stalks



pubescent, glandular. Fruit small, round, dark purplish-red, bloom rather thick, stem of medium length, stout; skin thick; flesh of fair quality; stone semi-cling, oval, strongly convex on the sides, sharp on the edge but not margined. Ripe September 11. Tree productive, but fruit too small to be ranked as valuable.

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**KICKAPOO.** (*Prunus Americana.*)

Planted in 1894. Not yet fruited. Trees of slow growth and straggling habit. Leaves large, broadly lanceolate, sharply and irregularly serrate, stalks glandular.

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**KOPP.** (*Prunus Americana.*)

Trees of good form and fair vigor, producing some drooping branches. Leaves large, dark green, sharply serrate; stalks red, pubescent, mostly glandless. Fruit medium to small, round, deep red, shading into the green ground, this mottled with white dots; skin thick; flesh firm, of good sub-acid flavor, sweet when fully ripe; stone nearly free, oblong, pointed, strongly convex, smooth. Ripe September 1. A productive variety.

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**LATE ROLLINGSTONE.** (*Prunus Americana.*)

Trees of moderate vigor, forming round compact heads. Leaves of medium size, obovate-oblong, short acuminate, irregularly and unequally crenate; young shoots red, smooth, shining; stalks glandular, pubescent. Fruit medium in size, round, flattened at both ends, deep red, shading into light red; stem of medium length; skin thick; flesh firm, of excellent quality. Stone cling, broad-oval, sides moderately convex, smooth. Ripe September 11. Not to be distinguished from Rollingstone. Even in time of ripening there appears to be no difference here.

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**LE DUC.** (*Prunus Americana.*)

The trees planted in 1894 are still rather small, but stocky and well-formed; they fruited heavily in 1897. This year they bloomed full, but matured a very light crop. Leaves large, light green, sharply serrate; stalks glandular,

pubescent on inner side; young wood glabrous. Fruit of medium size, round, waxy yellow shaded with red; skin thick; flesh juicy, sweet and rich; suture obsolete; stone roundish-oval with convex sides, semi-cling. Ripe August 25. Very productive. A good variety.

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LEONARD. (*Prunus Americana*.)

Trees of same size and appearance as those of Le Duc. Leaves large, rather short and broad, doubly and sharply serrate, stalks glandular. Fruit medium in size, round, dark red and mottled red on green ground; flesh not firm, quality only fair, acid; stone cling, small, smooth, roundish-oblong, with a rather sharp margin. Ripe September 1.

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LITTLE BLUE DAMSON. (*Prunus domestica*.)

Represented by three trees grown at the station, two of which are on Marianna stocks, one on *Prunus Americana*. They were set in 1895. There is no appreciable difference in size, but the one on *Prunus Americana* is overtopping the stock and will probably be short-lived. In habit the trees are upright and the growth is vigorous. Leaves of medium size, dark glossy green, only moderately crinkled, stalks usually without glands. Fruit small, oblong, cavity scarcely apparent, no suture; color very dark blue, almost black with heavy blue bloom; stem short and stout, flesh firm, decidedly acid; stone free, small, oblong, flat, rough. An abundant bearer, but fruit too small to be valuable.

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MARION. (*Prunus Americana*.)

Trees forming round, symmetrical heads; leaves of medium size, oval, sharply serrate, the teeth overlapping; stalk slender, glandless, or occasionally with one or two small glands; young shoots slender, glabrous. Fruit medium to large, round, flattened at lower end; purplish-red on orange ground, bloom thin; stem long and slender; skin thick; flesh sweet, juicy, of good flavor; stone semi-cling, rounded at base and pointed at the stem end; sides convex, margin rounded. Ripe September 15. Productive.

MARYLAND. (Classed by J. W. Kerr with *Prunus Besseyi*.)

This variety originated with J. W. Kerr of Denton, Md., and is a seedling of Utah Hybrid. The latter is of doubtful origin. Professor Waugh thinks it a probable hybrid between *Prunus Watsoni* and *Prunus Besseyi*.\* Our trees came from Mr. Kerr in 1894. They are the most straggling in habit of any in the orchard, producing many very long, slender, light red shoots, which are projected horizontally or downward. Apparently perfectly hardy here. Leaves of medium size, elliptical, acute or short acuminate, crenate; stalks glandular. Fruit small, spherical, color dark brownish-red, shading to light red on green ground; suture obsolete; flesh soft, watery, quite sweet and pleasant to the taste; stone cling, short, obliquely-oval, rounded at both ends, rough. Ripe August 20.

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MINER. (*Prunus hortulana* var. *Mineri*.)

One of the varieties planted in the original orchard. There are now ten trees, all well formed and healthy. They have borne for several years and are productive, but occasionally the season is too short and the fruit does not mature. Leaves large, broad, often obovate, short acuminate, evenly crenate; stalks glandular. Fruit medium in size, nearly spherical or round-oblong; deep red over greenish-yellow ground; stem long, slender; flesh firm and of very good flavor; stone cling, broad, short pointed at both ends, slightly roughened. suture obsolete. Ripe September 29 in 1897; September 22 in 1898.

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MINNETONKA. (*Prunus Americana*.)

Planted in 1894. Trees of slow growth, small, with bushy tops, quite free from thorns; young branches densely pubescent. Leaves large, broadly oval, dark green, coarsely serrate, stalks stout, usually glandless. Fruit small, oblong or oval, red on yellow ground; skin thick, flesh firm, rather acid, stone cling. Ripe September 11.

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\* Vermont Station, 10th Report (1896-7), p. 103.



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MISSOURI APRICOT. WILD GOOSE GROUP. (*Prunus hortulana*.)

Trees grown at the station and set in orchard in 1895; fruiting first in 1897. Of moderate vigor, inclined to be irregular in habit. Leaves of medium size, ovate, coarsely and sharply serrate, pubescent below; stalks glabrous, mostly glandless. Fruit medium to large, roundish, slightly narrowed at stem end, truncate at apex, sometimes indented, stem long; color waxy yellow with red cheek next the sun, mottled all over with small light-colored dots; flesh firm, sweet, rich; stone cling, short and broad, rounded at apex, pointed at stem end, sides convex. Ripe August 29. One of the desirable varieties.

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MOON. (*Prunus Americana*.)

Trees planted in 1894 bore a few fruits in 1896, a heavy crop in 1897, and a light crop in 1898; they are not vigorous in appearance, and grow very slowly; young branches light colored; leaves medium in size, obovate, coarsely and irregularly serrate, stalks glandular. Fruits medium, round or slightly oblong, deep red or mottled on yellow ground, suture obsolete; skin thin, flesh moderately firm, of good flavor, sub-acid; stone cling, short oval, strongly convex, with no prominent margin. Ripe September 5.

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OCHEEDA. (*Prunus Americana*.)

Trees of slow growth, forming round tops and producing many drooping branches, very thorny. They were planted in 1894, began bearing in 1896, gave a good crop in 1897 and a medium crop in 1898. Leaves large, oblong, acuminate, dark green, sharply and deeply serrate, pubescent below; stalks glandless or occasionally with two small glands, red, pubescent. Fruit of medium size, round-oblong; red on lemon-yellow ground with thick bloom; stem long; skin thick, flesh firm, of good flavor; stone cling, large, long-pointed, strongly convex on the sides, margin sharp, surface smooth. Ripe September 11.

**OGON. JAPANESE GROUP.** (*Prunus Americana*.)

Trees of very vigorous growth, but killing back to such extent each winter that they have borne no fruit. Young twigs light-colored, outer bark on two-year-old wood greenish-brown, showing many lenticles and cracks, on older wood becoming dark colored. Leaves lanceolate, glossy, light-green, crenate and glandular-denticulate; stalks short, glandular. Top grafts on native *Prunus Americana* inserted in 1894 have fruited for four seasons. Our description of the fruit is drawn from specimens produced in 1897. Round-oblong, slightly flattened at apex, oblique at stem end, cavity rather shallow; suture inconspicuous; color dull yellow with thin whitish bloom; stem short, stout; stone free, oval, sides strongly convex, margin prominent and sharp; flesh thick, firm, meaty, of inferior quality. Ripe Augt 14. Plate XII.

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**PEFFER'S PREMIUM.** (*Prunus Americana*.)

Trees planted in 1894 are still quite small, but well formed; young wood glabrous. Leaves medium, broadly-ovate, light green, more or less doubly serrate, the teeth short, stalks red, with or without glands. Fruit of medium size, round, rather abruptly flattened at both ends; suture obsolete; color deep red on yellow ground, conspicuously marked by "leather cracks" about the stem end; bloom thin; flesh firm, quality good; stone cling, circular, sides convex, sharp on the margins, smooth. Season medium; ripe September 11.

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**PENNOCK'S HYBRID.** (*Prunus Besseyi* X *Prunus Americana*.)

A few years since, in the nursery of Mr. C. E. Pennock, of Bellvue, there appeared among a lot of seedlings of *Prunus Besseyi*, one tree that, while bearing the flowers of *Prunus Besseyi* had the habit and foliage of *Prunus Americana*. The fruit borne by this tree is nearly the size of wild *Prunus Americana* but in color and flavor like *Prunus Besseyi*. The mixture of characters suggested hybridity and led Mr. Pennock to experiment in that direction. Pollen of *Prunus Americana* was successfully used on the stigmas of *Prunus Besseyi* and several hybrids resulted. These all resemble the plum in habit, but have the small flowers of the cherry. The leaf characters are intermediate, but generally most like the male parent. The fruit of most of the trees is



not valuable, being small and very acid. The color in all is dark, and in general much like the cherry. One tree, however, produces fruits that are considerably larger and much better than any of the others. It is to be introduced and may prove an acceptable addition to the list of varieties. This tree is of spreading habit, in general appearance like varieties of *Prunus Americana*. Leaves medium in size, varying from ovate to lanceolate. Flowers small, produced in profusion. Fruit of medium size, spherical; color deep blue, with light bloom; flesh firm, of excellent flavor, possessing none of the astringency so noticable in the fruit of the other hybrids. The tree in bloom is illustrated by plate XIII, and a branch showing fruit in figure 1, plate XIV. It is worthy of further trial.

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**PRAIRIE FLOWER.** (*Prunus hortulana*, var. *Mineri*.)

Represented by nine old trees of uncertain age, and one tree planted in 1894. The young tree fruited in 1897, the others have born for several years. The old trees are fully developed, as large as the trees of Miner, and of the same appearance. Leaves large, broadly to narrowly ovate-lanceolate, evenly crenate, lower surface pubescent, stalks long, stout, glandular. Fruit of medium size, round-oblong, obscurely pointed; color red on yellow ground, flecked all over with small light dots; suture evident; stem of medium length, stout; skin thin; flesh firm, sub-acid, of fair quality; stone cling, rather broad, short pointed at both ends, margin rather sharp, slightly roughened. Ripe September 21. Very productive.

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**PURPLE YOSEMITE.** (*Prunus Americana*.)

In character of tree very closely resembling the wild plant: very thorny, and irregular in habit. Leaves of medium size, ovate or obovate, acuminate, doubly serrate, dark green, pubescent below; stalks glandless, or occasionally with two small glands. Fruit large, round-oblong, flattened laterally; color deep purplish-red; skin thick; suture obsolete; flesh firm, of fair quality; stone cling, flat, rounded at the ends, rather rough, margins not sharp. Season medium to late. Ripe September 24.



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**ROCKFORD.** (*Prunus Americana.*)

Our trees planted in 1894 are still rather small, but thrifty in appearance, forming round regular tops. Leaves large, coarsely and deeply serrate, short acuminate; stalks dark red, pubescent, mostly glandless. Fruit of medium size, oblong, somewhat pointed, broad at base; color dark red on green ground; skin thin; suture inconspicuous; flesh firm, very acid until quite ripe, then of good quality; stone cling, broad at stem end and tapering to a rather acute, thick apex, sides strongly convex, margin narrow, but sharp. Productive, early; ripe August 31.

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**ROLLINGSTONE.** (*Prunus Americana.*)

Trees typical of the species, well-formed and of fair vigor. Leaves large, broad, irregularly crenate; color dark green, stalks mostly glandless. Fruit large, round, flattened at both ends; deep red shading to pink on yellow ground; stem of medium length, skin thick; flesh firm, good; stone cling, broad oval, sides convex, margins sharp, smooth. Season medium, ripe September 12.

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**RUSSIAN No. 2.** (*Prunus domestica*)

Trees forming roundish heads, and making less growth than other varieties of the same class. Leaves of medium size, broad, dull green, evenly crenate; stalks short, glandless. Fruit of medium size, inclined to be irregular in shape, often more or less constricted at stem end, and sometimes flattened at distal end; suture apparent, more deeply colored than surrounding parts; color deep purple, with heavy blue bloom, stem short, of medium length; flesh firm, sub-acid; quality only fair; stone free. Season early, ripe August 15.

---

**SPEER.** (*Prunus Americana*)

Small, but vigorous trees of spreading habit, producing long, slender branches. Leaves large, broad, acuminate, deeply and sharply serrate, dark green; stalk red, nearly glabrous, usually bearing small glands. Fruit medium in size, round-oblong, often contracted about the stem; suture evident; color purple-red on yellow ground; stem short, slender; skin thick; flesh firm and of good quality; stone cling, short-oblong, rather flat, ends blunt. Season medium, ripe September 17. Very productive.

---

**SUNSET.** (*Prunus Americana.*)

This variety originated with Mr. C. E. Pennock, of Bellevue, Colorado. We have one tree planted in 1897 that produced a few fruits this season. The tree is well-formed with a somewhat spreading habit. Leaves of medium size, broadly lanceolate, margin doubly and irregularly crenate, stalks glandular. Fruit medium to large, oval or oblong, stem rather long, slender; color deep red on yellow ground, beautifully shaded as it approaches ripeness; suture apparent; flesh firm, of excellent quality. Early; ripe August 25. The original tree shows great productiveness, which with the handsome appearance of the fruit, and its good quality, recommends the variety as a valuable acquisition. Fig. 2, Plate XIV.

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**VAN BUREN.** (*Prunus Americana*, var. *mollis*.)

Trees of slow growth, appearing like dwarfs; tops well-formed, spreading; leaves broad, doubly serrate, dark green, stalks ashy-pubescent, glandular; fruit of medium size, spherical, suture obsolete; color deep waxy yellow, in part over-spread with light red and having a deep red cheek; stem stout, of medium length; skin thick; flesh sweet and rich; stone free, flat, rather broad, margin sharp but not winged. Ripe September 22. Very productive. One of the most promising varieties. Plate XV.

---

**WEAVER.** (*Prunus Americana.*)

Our trees planted in 1894 are larger than those of any other variety planted at the same time. They are vigorous and well-formed. The tendency to produce long slender branches is quite marked in this variety. Leaves large, obovate or oval, acuminate, somewhat pubescent below, leathery in texture, dark green, deeply serrate; stalk long, stout, glandless, or with occasional small glands. Fruit medium to large, round-oblong; suture evident, sides often unequal; color purplish-red on yellow ground, the red mottled with light dots; flesh firm, sweet when ripe, of good flavor; stone semi-cling, abruptly pointed, smooth. Ripe September 18. Plate XVI.



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**WINNEBAGO.** (*Prunus Americana.*)

Trees very vigorous, well-formed. Leaves large, broad, sharply serrate, produced in great abundance; stalks short, stout, glandular. Fruit medium to small, round, inclined to be irregular and one-sided; stem long, slender, cavity deep; color deep red on yellow ground; skin thin; flesh yellowish, soft, of inferior flavor, granular in texture; stone nearly free, elliptical, somewhat oblique; rather flat, rounded at both ends, roughish. Ripe September 18. Plate XVII.

---

**WOLF.** (*Prunus Americana.*)

Vigorous growing trees of spreading habit. Leaves large, ovate, acuminate, closely and sharply serrate, leathery in texture; stalks stout, ashy pubescent; on some trees wholly glandless, on others small glands are not uncommon. Fruit medium to large, round to round-oblong, slightly flattened, sometimes tapering somewhat toward the stem; stem short, stout, set in a small cavity; suture obsolete; color when ripe uniformly deep red, with heavy purple bloom; skin thick; flesh firm, of good quality; stone free, rather small, pointed at stem end, sides strongly convex, margin sharp and prominent, smooth. Season medium, ripe September 16. Fruit Fig. 2, Plate VI; Tree Plate XVIII.

---

**WYANT.** (*Prunus Americana.*)

Trees stocky, forming round heads, of slower growth than Wolf or Weaver. Leaves medium, crisp in texture, sharply serrate, dark green; stalks pubescent and glandular. Fruit large, round-oblong, flattened at apex; cavity large and deep; color purple red on yellow ground; stem short, stout; skin thick; flesh firm, of good flavor; stone free or nearly so, large, oblong, flat. Ripe September 18. Fruit Fig. 1, Plate VII.

---

**YELLOW SWEET.** (*Prunus Americana.*)

Trees small, stocky, very thorny; leaves large, oval-oblong, irregularly crenate, stalks commonly glandless. Fruit large, round, color yellow, lightly shaded with red, bloom thin; suture apparent; stem short, stout; skin thin; flesh firm, juicy, rich; stone cling, oval, pointed at both ends, sides convex, margin sharp. Ripe August 31. A very promising variety. Fruit Fig. 2, Plate VII; Tree Plate XIX.



## REFERENCE TO PLATES.

### PLATE I.

Fig. 1, Yellow Sweet; Fig. 2, Wolf, showing lack of affinity between stock and scion. The stock is being overgrown.

Fig. 3, Plate of Weaver plums, reduced nearly one-half.

### PLATE II.

Illustrates the system of irrigation practiced.

### PLATE III.

Showing the effects of the "Shot-hole fungus" (*Cylindrosporium Padî Karst.*)

### PLATE IV.

Fig. 1, Black knot of the plum and cherry, (*Plowrightia morbosa* (Schw.) Sacc.)

Fig. 2, Plum pockets. (*Exoascus Pruni Fckl.*)

### PLATE V.

Fig. 1, Cheney; Fig. 2, Deep Creek; reduced nearly one-half.

### PLATE VI.

Fig. 1, Forest Rose; Fig. 2, Wolf; reduced nearly one-half.

### PLATE VII.

Fig. 1, Wyant; Fig. 2, Yellow Sweet: reduced nearly one-half.

### PLATE VIII.

Cheney.

### PLATE IX.

Deep Creek.

### PLATE X.

Forest Rose.

### PLATE XI.

Hawkeye.

### PLATE XII.

A branch of Ogon from top graft on P. Americana.

### PLATE XIII.

One of Mr. C. E. Pennock's hybrids between P. Besseyi and P. Americana in bloom.

### PLATE XIV.

Fig. 1, Fruit of Mr. C. E. Pennock's hybrid between P. Besseyi and P. Americana.

Fig. 2, Sunset plum, originated by Mr. C. E. Pennock.

### PLATE XV.

Van Buren.

### PLATE XVI.

Weaver.

### PLATE XVII.

Winnebago.

### PLATE XVIII.

Wolf.

### PLATE XIX.

Yellow Sweet.

Plates 13 and 14 are from photographs by S. H. Seckner, all others from photographs by the author.

PLATE I.

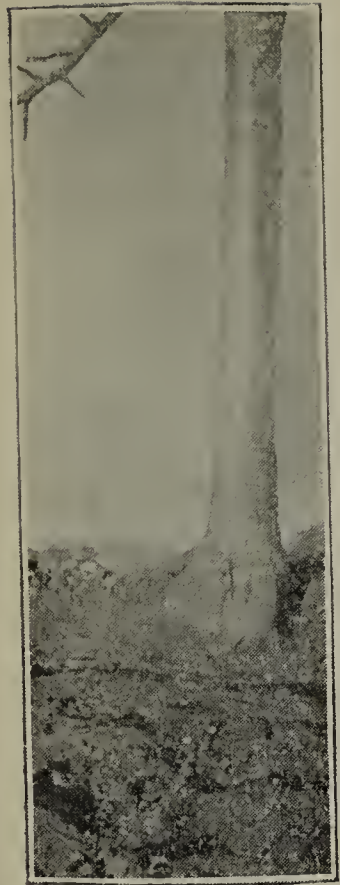


Fig. 1.



Fig. 2.



Fig. 3—Weaver.



PLATE II.—Irrigation.

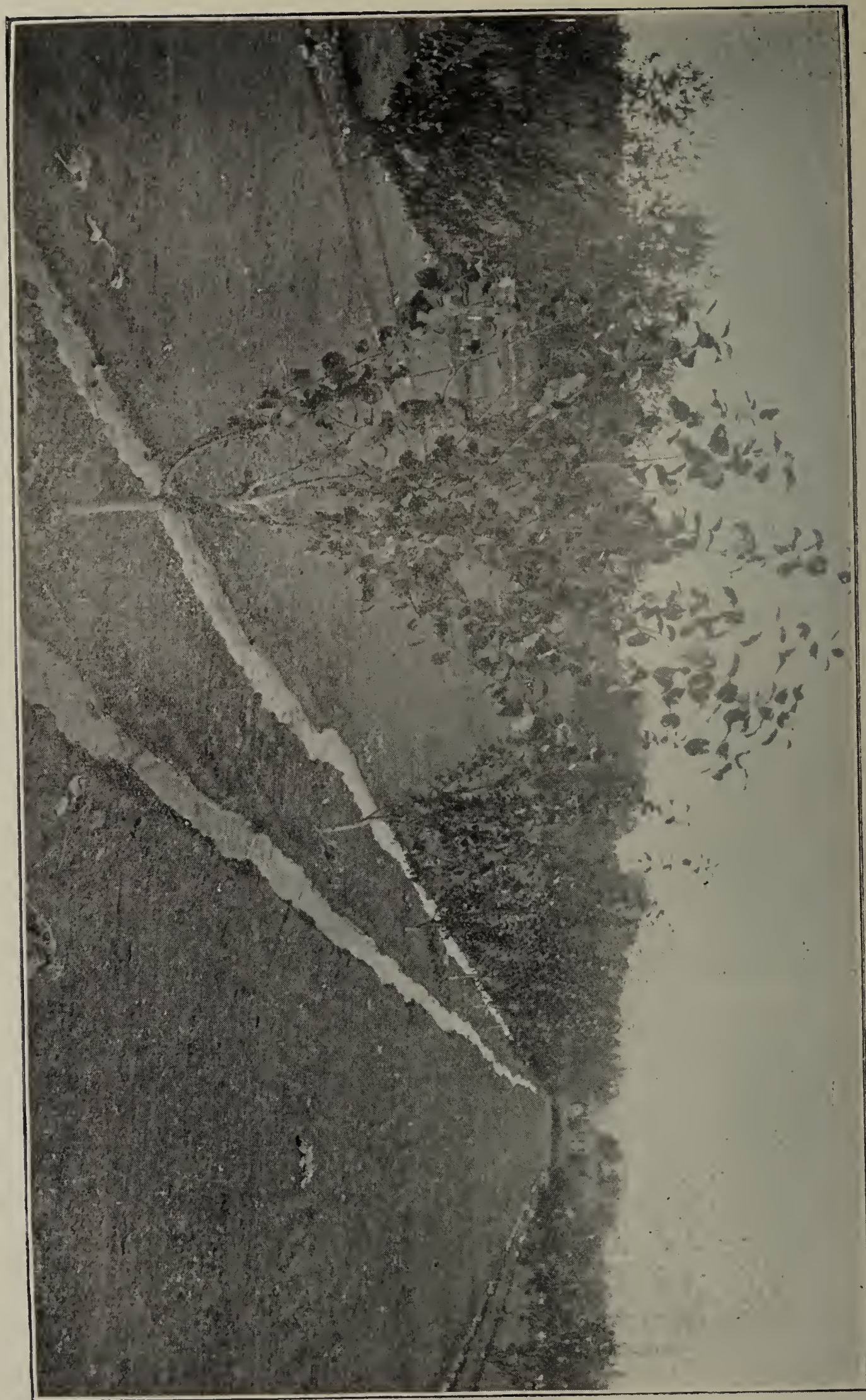




PLATE III.



Plum Leaves.

PLATE IV.



Fig. 1—Black Knot.



Fig. 2—Plum Pockets.





Fig. 1—Cheney.



Fig. 2—Deep Creek.



PLATE VI.



Fig. 1—Forest Rose.



Fig. 2—Wolf.



PLATE VII.



Fig. 1—Wyant



Fig. 2 – Yellow Sweet.



PLATE VIII.



Cheney.



PLATE IX.



Deep Creek.

PLATE X.



Forest Rose.



PLATE XI.



Hawkeye.

PLATE XII.



Ogon.



PLATE XIII.

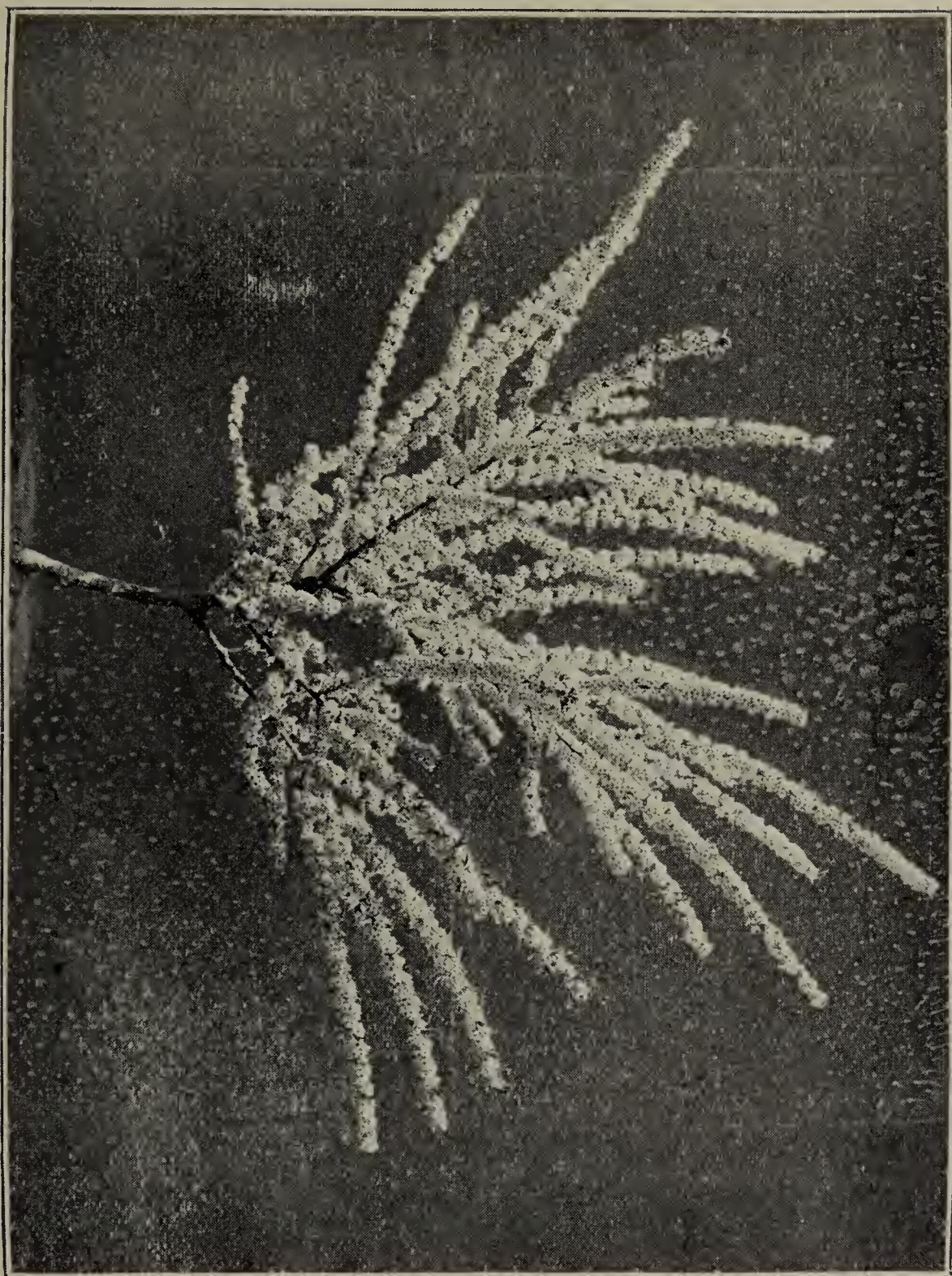




PLATE XIV.



Fig. 1—Hybrid.



Fig. 2—Sunset.



PLATE XV.



Van Buren.

PLATE XVI.



Weaver.



PLATE XVII.



Winnebago.

PLATE XVIII.



Wolf.



PLATE XIX.



Yellow Sweet.





AGRICULTURAL EXPERIMENT STATION,

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THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

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BULLETIN NO. 51.

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SUGAR BEETS IN COLORADO IN 1898.

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*Approved by the Station Council.*

*ALSTON ELLIS, President.*

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FORT COLLINS, COLORADO.

MARCH, 1899.

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# SUGAR BEETS IN COLORADO IN 1898.

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By W. W. COOKE.

For several years the Station has been carrying on experiments in Colorado on the adaptation of the sugar beet to the conditions of soil and climate found here. During 1898 these tests were conducted on a larger scale than ever before. It can be said in general that the results of the season of 1898 are so conclusive, that we may feel justified in saying that Colorado can raise as good sugar beets and as large crops of beets as any place in the world. We purpose now to consider this point as settled, and future experimental work with sugar beets will be directed toward some of the minor points of methods of irrigation, times and distances of planting, etc.

The work of 1898 was distinguished from that of previous years in that it was done largely in connection with the Denver Chamber of Commerce, and cash prizes were offered for the best crops of sugar beets, thus affording an incentive to better care of the crop. It is believed that the inducement thus offered was a powerful factor in the good results obtained, yet the value of the prizes was as nothing compared with the value of the crop if raised for a factory. So that it is a fair presumption that what was done under the stimulation of the Denver Chamber of Commerce, prizes would be the common result under factory conditions.

The work of the season of 1898 may be grouped under four headings :

1. The experiments conducted on the College Farm at Fort Collins and on the sub-station at Rocky Ford, with reference to methods of growing sugar beets.

2. Experiments conducted at these two places and at about twenty other places in the State, with reference to the quantity and quality of sugar beets grown from seed raised in the United States as compared with seed grown in Europe.

3. Competitive tests for the prizes offered by the Denver Chamber of Commerce in connection with the County Commissioners of various counties.

4. General tests in the parts of the State above irrigation or in those irrigated sections that did not take interest enough in the matter to co operate in the matter of prizes.

The beet seed was obtained principally from the United States Department of Agriculture, but some, also, from the Oxnard Sugar Co., of Grand Island, Nebraska, through the efforts of the officials of the Union Pacific, Denver & Gulf Railroad; some from the sugar factory at Rome, N. Y., through the efforts of Mr. M. B. Colt, of Alamosa, and when all these sources of supply failed, the Denver Chamber of Commerce bought, in open market, enough seed to supply the remainder of the requests. In all, about four thousand pounds of seed were distributed to two thousand three hundred persons. In each case the seed was delivered free of charge to the person making the tests.

All the analyses on which this bulletin is founded were made by the Chemical Section of the College at Fort Collins. There were eight hundred and twelve samples analyzed at Fort Collins.

Through the courtesy of the U. S. Department of Agriculture the franking privilege was given to the Station for the sugar beet work, and all the seed and several thousand pounds of the beets for analysis were sent through the mail postage free. In addition the railroads of the State, particularly the Union Pacific, Denver & Gulf, Denver & Rio Grande, and Atchison, Topeka & Santa Fe, took a lively interest in the experiments and furnished transportation that materially facilitated the work.

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## EXPERIMENTS AT FORT COLLINS AND ROCKY FORD ON METHODS OF RAISING SUGAR BEETS.

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These tests can be grouped under the following headings:

1. Different dates of planting.
2. Planting on freshly plowed ground as compared with ground plowed a few days before planting.
3. Seed irrigated at planting as compared with that not irrigated.
4. Soaking seed before planting.
5. Sowing at the bottom of a three-inch furrow.
6. Different depths of planting.
7. Transplanting.
8. Different distances of thinning.
9. Different dates of thinning.
10. Variety tests.
11. Number of irrigations.



Each of these tests will be considered by itself, but at the outset it is necessary to make some explanations.

The following general statements apply to all the experiments at Fort Collins. The piece selected was a rather heavy clay loam, sloping slightly to the south. The ground had been heavily manured the spring of 1896 at the rate of nearly sixty tons per acre of well-rotted stable manure. It was cropped during 1896 and 1897 with corn. The spring of 1898 it was plowed in sections. A part of the section was planted the day it was plowed, the rest was allowed to lie from two to four days before it was planted. The seed was sown with an ordinary wheat drill in rows twenty-four inches apart. A few rows that will be specially mentioned were sown with a hand garden drill in rows eighteen inches apart. As soon as the beets broke through the ground so as to define the rows, they were wheel-hoed by hand. Later they were thinned, hand-hoed, cultivated three times with a horse cultivator, and twice irrigated, on June 27 and July 19.

The first set of samples was taken the last of September, after a period of long continued and severe drought. The last samples were taken October 22. Between these two dates there had been several rains, giving a total precipitation of three-fourths of an inch and dampening the beets to the bottom of the furrow. The beets were dug during the following week, with no further rain. Each of the 176 rows was dug in two parts and each part weighed separately. Every beet on the field was counted, to get the stand under the various conditions, and about half of them were counted the second time. This work involved about a thousand weighings and the counting of over sixty thousand beets.

The plantings at Fort Collins were made May 10, May 27 and June 15, with supplementary plantings May 13 and May 31. It had been expected to make four plantings, but a very heavy snow storm set in the last of April, with a total precipitation of three inches. None of this ran off and the ground was thoroughly soaked to a depth of eight inches. It was not until the second week in May that the soil dried out enough so that it could be worked.

This storm had a far reaching effect on the sugar beet work of the season. It saturated the ground without packing it, and to this is largely due the almost perfect germination obtained and the small influence observed from soaking the seed or irrigating at time of planting. The influence of this storm was still felt at the time of the second planting, the last of May, and the ground was hardly dried out by the last planting, the middle of June. The same storm will be referred to later with reference to its effect on the beets at Rocky Ford.

Before giving the detailed record of the various tests, it may be well enough to notice the analyses of the two sets of samples. Both

sets were taken in the same way. Every tenth beet was taken from two contiguous rows until about a dozen beets had been dug. These were at once topped, cleaned by brushing or scraping, or in a few cases by washing, and weighed on scales accurate to the quarter of an ounce. If they were analyzed the same or the next day no account was taken of the small amount (about two per cent.) that they had dried out between digging and analyzing. If they stood longer than two days before they were analyzed, a correction was made in both total solids and sugar for the water that had dried from the beets after the second day. All of the analyses given in this section on methods of raising beets and in the section of this bulletin on tests of different sources of seed are the corrected analyses after making allowance for the drying out after the second day. In actual factory practice the beets seldom reach the factory until the third day after digging, and often not until much longer periods. So that it is probable that had these beets been raised and delivered to a factory they would have dried out a little more and tested a little higher than the figures given in this bulletin.

About fifty samples were taken the last of September, and an equal number October 22. The average of the first set is 15.43 per cent of sugar in the beet and 78.6 purity. The second set averaged 16.38 sugar and 78.1 purity, thus indicating a small gain in sugar and slight loss in purity between the first and second samplings. If these fifty tests are divided into five sets, according to the dates of planting, as will be given later, the last four sets give 14.97 sugar and 77.2 purity for the first samples, and 16.24 sugar with 77.6 purity for the samples three weeks later. Thus, they show an increase in sugar with but little change in purity. The samples from the first planting average 17.28 sugar and 84.2 purity for the first set, and 16.96 sugar with 79.7 purity for the last samples. A study of the ground gives some explanation of the cause of these differences. The ground first planted was so damp at the time it was worked, that it was somewhat packed by the working, and consequently suffered more from the late drought. At the time the samples were taken, the last of September, the leaves of the beets on this part of the field were so badly wilted as to touch the ground. The beets were really dried out in the ground. When the rain came they absorbed water and showed a lower test, with a change in purity, from a slight second growth.

It can be said, then, that, on the whole, the beets gain one per cent. of sugar during the three weeks between the two times of sampling, but there are so many apparent exceptions to this general statement, due to differences in sampling and analyzing, that it is deemed best to use the analyses of both sets of samples.



# 1. DIFFERENT DATES OF PLANTING.

A section of the ground was plowed May 10, part planted at once and the remainder planted May 13. A second section was plowed May 27, and planted on that day and on May 31. The third section was both plowed and planted June 15. The rows were two feet apart and 177 feet long; the intention was to thin to six inches, so as to have one beet for each square foot of surface. In the following table, a "perfect stand" would have been one beet for each six inches of row :

| Row.         | Date planted | Per ct. of perfect stand. | Average distance apart in row. Inches. | Average weight of beets. Lbs. | Test.         | Sugar in beet. | Purity. | Weight of crop in tons per acre. | Pure sugar per acre. Lbs. |
|--------------|--------------|---------------------------|----------------------------------------|-------------------------------|---------------|----------------|---------|----------------------------------|---------------------------|
| 21-92.....   | May 10       | ....                      | ....                                   | ....                          | First .....   | 17.28          | 84.2    | ....                             | .....                     |
| " .....      | "            | ....                      | ....                                   | ....                          | Second .....  | 16.96          | 79.7    | ....                             | .....                     |
| " .....      | "            | 88                        | 6.8                                    | 0.92                          | Average ..... | 17.12          | 82.0    | 17.8                             | 6095                      |
| 103-120..... | May 13       | ....                      | ....                                   | ....                          | First .....   | 15.24          | 74.3    | ....                             | .....                     |
| " .....      | "            | ....                      | ....                                   | ....                          | Second .....  | 17.26          | 78.8    | ....                             | .....                     |
| " .....      | "            | 83                        | 7.2                                    | 0.90                          | Average ..... | 16.25          | 76.6    | 16.3                             | 5296                      |
| 141-155..... | May 27       | ....                      | ....                                   | ....                          | First .....   | 16.18          | 79.9    | ....                             | .....                     |
| " .....      | "            | ....                      | ....                                   | ....                          | Second .....  | 16.54          | 77.4    | ....                             | .....                     |
| " .....      | "            | 72                        | 8.3                                    | 1.09                          | Average ..... | 16.36          | 78.7    | 17.4                             | 5693                      |
| 156-161..... | May 31       | ....                      | ....                                   | ....                          | First .....   | 15.37          | 77.3    | ....                             | .....                     |
| " .....      | "            | ....                      | ....                                   | ....                          | Second .....  | 17.05          | 78.9    | ....                             | .....                     |
| " .....      | "            | 71                        | 8.4                                    | 0.91                          | Average ..... | 16.21          | 78.1    | 14.2                             | 4604                      |
| 165-176....  | June 15      | ....                      | ....                                   | ....                          | First .....   | 13.01          | 77.5    | ....                             | .....                     |
| " .....      | "            | ....                      | ....                                   | ....                          | Second .....  | 14.11          | 75.5    | ....                             | .....                     |
| " .....      | "            | 34                        | 18.0                                   | 1.27                          | Average ..... | 13.56          | 76.5    | 9.3                              | 2522                      |

For the purpose of studying the effect of the main three different dates of planting, the preceding table may be summarized as follows :

| Row.         | Date planted. | Per cent of perfect stand. | Average distance apart in row. Inches. | Average weight of beets. Lbs. | Per cent of sugar in beet. | Per cent purity. | Weight of crop in tons per acre. | Pure sugar per acre. Lbs. |
|--------------|---------------|----------------------------|----------------------------------------|-------------------------------|----------------------------|------------------|----------------------------------|---------------------------|
| 21-120.....  | May 10-13     | 87                         | 6.9                                    | 0.91                          | 16.85                      | 79.3             | 17.5                             | 5897                      |
| 141-162..... | May 27-31     | 72                         | 8.3                                    | 1.00                          | 16.31                      | 78.3             | 16.6                             | 5415                      |
| 165-176..... | June 15       | 34                         | 18.0                                   | 1.27                          | 13.56                      | 76.5             | 9.3                              | 2522                      |

The showing against the late planting is very decided. It produced less than half as much sugar as either of the others. It is evident that the small weight of crop is due, primarily, to the poor stand, since, even planting the middle of June, the beets average larger than those planted earlier. But, with only a third of a stand and the beets eighteen inches apart, the extra size did not compensate for the smaller number of beets. The poor stand is due to hot, dry weather, and, as will be noticed more at length in another place, even irrigating at the time of planting did not much increase the germination.

The difference between the crops of the May 10 planting and that of May 27, is not large, indicating that profitable crops may be raised, even though the seed is not planted until the last week in May. The difference in the stand in this case is, undoubtedly, due to the drying out of the ground, rather than to the greater heat. Though differences in sugar and purity are not large, yet these differences are in favor of the earlier planting. The analyses of the beets from the June 15 planting, show that the crop did not reach nearly to the degree of ripeness attained by the earlier plantings.

There is nothing in these experiments to show whether still better returns would be obtained by planting in April, and, unfortunately, the test of this point, made at the Rocky Ford sub-station, was so injured by a severe hailstorm as to offer little light on this point.

The beets at Rocky Ford were planted at four different dates, April 18, May 2, May 16 and June 1. As the season there is about two weeks earlier than at Fort Collins, these dates are about the same, so far as the season is concerned, as those used at Fort Collins, with the addition of one earlier date. The beets were planted in good mellow garden soil, in rows eighteen inches apart and thinned to nine inches apart in the row.

As noted above, a severe hailstorm, on June 6, interfered seriously with the experiment. The plantings of April 18, May 2 and May 16, were well up at the time and were cut even with the ground, allowing the later planting to approach them in growth. When the present writer visited the field, the middle of July, the eye could scarcely tell any difference between the first three plantings.

Two sets of samples were taken of each of these plantings, the first October 8 and the second October 29. The crop was harvested during the next week and the beets counted from several rows of each planting, so as to get the stand and the average size :



| Date of planting. | Per cent of full stand. | Average distance apart in row. Inches. | Average weight of beets. Pounds. | Weight of crop in tons per acre. | Pure sugar per acre. Pounds. |
|-------------------|-------------------------|----------------------------------------|----------------------------------|----------------------------------|------------------------------|
| April 18 .....    | 63                      | 9.5                                    | 0.96                             | 18.4                             | 6097                         |
| May 2 .....       | 57                      | 10.5                                   | 0.89                             | 15.1                             | 5138                         |
| May 16 .....      | 85                      | 7.0                                    | 0.64                             | 15.6                             | 5338                         |
| June 1 .....      | 90                      | 6.7                                    | 0.50                             | 13 8                             | 4857                         |

| Date of Planting. | TEST OF OCTOBER 8. |         | TEST OF OCTOBER 29 |         | AVERAGE.       |         |
|-------------------|--------------------|---------|--------------------|---------|----------------|---------|
|                   | Sugar in beet.     | Purity. | Sugar in beet.     | Purity. | Sugar in beet. | Purity. |
| April 18 .....    | 16.98              | 84.6    | 16.07              | 86.9    | 16 57          | 85.7    |
| May 2 .....       | 16.79              | 83.7    | 17.32              | 85.2    | 17.05          | 84.4    |
| May 16 .....      | 16.75              | 86 2    | 17.47              | 86.7    | 17.11          | 86.4    |
| June 1 .....      | 18.02              | 87.0    | 17.17              | 85.5    | 17.59          | 86.2    |

The beets at Rocky Ford ripened better than those on the College Farm. They show for the first three plantings about half a per cent more sugar and more than six per cent better purity than the first two plantings at Fort Collins. The crops from the earlier plantings at the two places are about equal. But while the last planting at Fort Collins never ripened and produced less than two-thirds the crop of the earlier plantings and not half as much sugar per acre, the last planting at Rocky Ford gives the best beets of all in quality and not much below the others in quantity. At both places the last of May seems to be as late as it is advisable to sow, although a crop can be obtained from beets sown considerable later. The averages of the two sets of samples at Rocky Ford are identical, showing that the beets had fully ripened before the first samples were taken. The intention was to take some earlier samples, but the letter of instructions was lost in the mail.

## 2. PLANTING ON FRESHLY PLOWED GROUND.

One of the greatest troubles in raising sugar beets is getting a good stand. If the seed is planted deep and the planting is followed by a rain, the ground packs and the seed cannot get through; if planted shallow and dry weather follows, the seed cannot get enough moisture to grow well. In the present case, there was a large amount of moisture in the ground at the time of plowing and the question was, will the amount that dries out in the first few days after plowing be enough to influence germination and growth. The table already given contains the figures of the test and the re-

sults are strikingly in favor of planting on freshly plowed ground. In the first case three days elapsed between plowing and planting; in the second case four days intervened. The four items of germination, sugar, purity and weight of crop are in each case in favor of the beets planted as soon as possible after the ground is plowed. These differences are not always large, though in the case of the weight of the crop they amount to one-seventh, but in the aggregate the difference would have a decided influence on the sugar value of the crop. The average of the two plantings on freshly plowed ground is 16.74 per cent sugar, 80.3 purity and 17.6 tons per acre. The beets planted three or four days after plowing give 16.23 per cent sugar, 77.3 purity and 15.3 tons per acre. Combining these figures, the first gives 4731 pounds of available sugar per acre, while the latter yields but 3839 pounds, a difference of nearly a thousand pounds of sugar, or something over ten dollars per acre in favor of immediate planting. In the light of these figures, it can be seen how important it is that if large areas are to be planted, they should be plowed in sections and each section planted the day of plowing.

### 3. IRRIGATING AT THE TIME OF PLANTING.

Three tests were made of irrigating the ground as soon as the seed was planted, as compared with allowing the seed to germinate from the moisture in the soil. In each case a small furrow was made some six inches from the seed, and water run in this furrow until it soaked sideways and wet the seed.

| IRRIGATED AT PLANTING. |                                |                                 |                      |         | NOT IRRIGATED AT PLANTING. |                                |                                 |                      |         |
|------------------------|--------------------------------|---------------------------------|----------------------|---------|----------------------------|--------------------------------|---------------------------------|----------------------|---------|
| Rows.                  | Number<br>beets<br>per<br>row. | Tons<br>per<br>acre of<br>crop. | Sugar<br>in<br>beet. | Purity. | Rows.                      | Number<br>beets<br>per<br>row. | Tons<br>per<br>acre of<br>crop. | Sugar<br>in<br>beet. | Purity. |
| 27-32.....             | 232                            | 15.8                            | 17.48                | 84.7    | 21-26.....                 | 243                            | 16.0                            | 17.84                | 85.7    |
| 45-56.....             | 338                            | 18.4                            | 17.77                | 86.4    | 33-44.....                 | 271                            | 17.8                            | 16.97                | 84.6    |
| 165-170.....           | 112                            | 9.9                             | 12.12                | 76.5    | 171-176.....               | 128                            | 8.1                             | 13.08                | 76.2    |
| Average.....           | 227                            | 14.7                            | 15.79                | 82.5    | Average.....               | 214                            | 14.0                            | 15.96                | 82.2    |

The results are closer than would be expected had the treatment been exactly alike, showing that so far as these tests are concerned there was no advantage from irrigating up the seed. It should be remembered, however, that this was on a soil very retentive of moisture, and which at the time the first two of these tests were made, was already well supplied with water. This soil also bakes easily and of course the bad effects of the hardening of the soil would go far toward counteracting the good effect of the extra moisture. It was expected that if irrigating up the seed was an ad-



vantage it would show most clearly in the last case, which was sown June 15 after the ground was quite dry. Here, however, the irrigation seemed to be a detriment, due probably to the baking of the soil.

While the above results are not favorable to the practice of irrigating up the seed when sown in ground as heavy as that of the College Farm, it does not follow that this may not be advantageous under other conditions and in other parts of the State. The present writer visited the farm of Mr. B. F. Wyckoff, at Rocky Ford, the past season, and saw there a large field of sugar beets with a perfect stand, that had been secured by irrigating up the seed. This field produced over 23 tons of beets to the acre. At Lamar he saw another perfect field of beets produced in the same way, on the farm of Mr. M. D. Parmenter. On remarking to Mr. Parmenter that at the College our greatest trouble was to get a stand, Mr. Parmenter replied that he always felt perfectly sure of that part of the business. His land was sandy enough so that it would not bake and had plenty of slope. He planted whenever he got ready, and then turned on the water. His perfect stand in 1898 was obtained with about four pounds of seed per acre.

On the lighter soils of the Arkansas valley, irrigating up the seed is a necessity, as the ground will not hold enough moisture to make a complete germination.

#### 4. SOAKING BEET SEED.

Two rows were sown with dry seed; two with half each of dry and soaked seed, and two with soaked seed, *i. e.*, seed that had been soaked in water for twenty-four hours before it was planted. Unfortunately, these tests being made on a small scale, were sown with a hand drill that did not do good work. Good results were obtained with the soaked seed, but no better than were obtained on neighboring rows with unsoaked seed. The test shows, therefore, neither advantage nor disadvantage from soaking the seed.

#### 5. SOWING AT THE BOTTOM OF A THREE-INCH FURROW.

It was thought that, adopting the idea of the trench method of raising potatoes, there might be some advantage from getting the beet seed deep in the ground. A small furrow was made with a hand plow, and then the beet seed sown with a hand drill at the bottom of this furrow. This put the beet seed nearly four inches below the surface of the ground, but left it only lightly covered. Three tests were made, including both early and late sowing. The stand was not so good as in the rows on each side sown at ordinary depths. The yield was once as good and twice poorer than from similar rows of ordinary planting. The sugar and purity were not perceptibly different from other plantings.

In connection with this and some other tests, there is a chance to compare the results of planting with a hand planter and a horse planter. Though we have a good hand planter, yet on the whole the horse planter, which with us is an ordinary wheat drill, has given the better stand and the larger weight of crop.

#### 6. DIFFERENT DEPTHS OF PLANTING.

The following tests were made with the grain drill, set to plant as nearly as possible at the desired depths.

| Row.         | Depth of planting. | Number beets per row. | Weight of crop per row. | Sugar in beet. | Purity. |
|--------------|--------------------|-----------------------|-------------------------|----------------|---------|
| 57-68.....   | ½ inch             | 360                   | 313                     | 15.51          | 76.1    |
| 147-149..... | " "                | 233                   | 237                     | 16.10          | 79.0    |
| 69-80.....   | 1 inch             | 358                   | 281                     | 17.00          | 78.7    |
| 150-152..... | " "                | 239                   | 284                     | 15.78          | 79.6    |
| 81-92.....   | 1½ inches          | 315                   | 279                     | 17.31          | 80.0    |
| 153-155..... | " "                | 270                   | 313                     | 16.76          | 85.0    |

With the first lot, rows 57-92, sown May 11, there is not much difference, but this slight difference both in stand and yield is in favor of the shallow planting. But it should be remembered that this seed was put into thoroughly damp, freshly plowed ground that was over a damp, almost wet, subsoil. The analysis is enough in favor of the deeper plowing to make the available sugar per acre the same for all three depths of planting.

At the later planting, May 27, rows 147-155, the ground was freshly plowed but had dried out considerably since May 11. In this test the stand, yield and quality are all in favor of the deepest planting, amounting in the comparison of the half inch with the one and a half inch to more than a third of the crop.

#### 7. TRANSPLANTING BEETS.

Some beet seed was sown in the greenhouse April 20 and the young beets transplanted to freshly plowed ground May 10. The rows were 18 inches apart and the beets 9 inches apart in the row. In the first part of the rows about three-fourths of the beets lived, but less than half of them in the rest of the rows, making an average of about one beet to each two square feet. The growth of the beets was satisfactory so far as weight was concerned. They averaged a little over one and a half pounds each, or 16.3 tons per acre. Not a single tap root grew in the whole four hundred beets; they were a mass of fibrous roots that lost at least a fifth in trimming. Their quality was the lowest of all the beets planted early in May, being 14.44 sugar and 74.3 purity.



The above beets were planted in damp ground without irrigation. The next day some more from the same lot were transplanted and irrigated as soon as set. The stand was even poorer than before, though it was supposed that the work had been done with greater care. The size of the beets and the quality were the same as in the first lot. The fibrous roots were not quite so numerous, but there was not a good beet in the whole lot. Seed was sown in the ground at this date, May 10, and on June 8 some of the small beets were transplanted to some neighboring rows. They grew poorly and not one-fourth of them lived. They were not so bad in shape as those from the greenhouse and the quality was better, but as a method of raising beets it proved a financial failure.

Transplanting from the greenhouse, both with and without irrigation, was tried on another lot of plants May 26. It was a hot day, and in spite of the immediate irrigation only a few of the beets lived.

On June 15 transplanting was again tried with some larger beets that had been sown in the ground May 13. These beets were set in running water, and though in the middle of the summer at least nine-tenths of them grew. They were far from good shaped, but they made a crop of 19.3 tons per acre, testing 15.91 sugar, with 79.7 purity.

On June 27 some more transplanting was done from the beets sown May 27. These beets were quite small. They were planted in running water and nearly all grew. They made a crop of 18.9 tons per acre, testing 17.00 sugar with 80.1 purity. Judged by yield and test, these beets show quite well, but they were not good shaped. They were transplanted with the greatest of care into running water and afterwards irrigated several times, so as to give the best possible chance. Better results could hardly be expected, but the method would not be a financial success.

#### 8. DIFFERENT DISTANCES OF THINNING.

The attempt was made to thin beets to 4 inches, 6 inches and 8 inches, but the thinning was so poorly done that the 4-inch and the 6-inch each averaged 8 inches apart, and the 8-inch rows averaged 10 inches apart. Three trials were made. The first two tests on beets planted May 10, show no regularity of results and only slight differences. The 4-inch and 6-inch rows are excellent duplicates. By combining these two and comparing with the other rows, there is a slight showing in favor of the first two in yield, sugar and purity, which leads one to judge that 8 inches is a better distance than 10 inches for two-foot rows. The late planting of May 27 is quite decidedly in favor of the thicker stand for yield, sugar and purity. The full figures are given below:

| Row.               | Intended distance apart. Inches. | Actual distance apart of beets. Inches. | Number of beets in One row. | Weight of crop in tons per acre. | Sugar in beet. | Purity. |
|--------------------|----------------------------------|-----------------------------------------|-----------------------------|----------------------------------|----------------|---------|
| 21 and 24 .....    | 4                                | 8                                       | 301                         | 16.1                             | 16.97          | 79.8    |
| 27 and 30 ... ..   | 4                                | 8                                       | 251                         | 15.6                             | 18.31          | 86.0    |
| 103 and 104 ... .. | 4                                | 8                                       | 272                         | 16.5                             | 16.52          | 75.1    |
| 22 and 25 .....    | 6                                | 8                                       | 215                         | 16.5                             | 17.63          | 83.0    |
| 28 and 31 .....    | 6                                | 8                                       | 251                         | 15.5                             | 17.55          | 83.2    |
| 105 and 106 .....  | 6                                | 8                                       | 293                         | 14.9                             | 16.54          | 78.3    |
| Average.....       | ....                             | 8                                       | 264                         | 15.8                             | 17.26          | 80.9    |
| 23 and 26 .....    | 8                                | 10                                      | 211                         | 15.5                             | 18.38          | 80.3    |
| 20 and 32 .....    | 8                                | 10                                      | 196                         | 16.2                             | 17.03          | 81.5    |
| 107 and 108 .....  | 8                                | 10                                      | 198                         | 13.4                             | 15.12          | 68.7    |
| Average.....       | ....                             | 10                                      | 202                         | 15.1                             | 16.69          | 78.6    |

Seeing that this form of the test was a failure, another trial of the same point was made by going through the rows that were intended to have the beets 4 inches apart and selecting twelve beets, each of which was just four inches on each side from the next nearest beet. The same was done with the 6 inch rows and the 8-inch rows. The following results were obtained :

| Row.           | Distance apart of beets Inches. | Average weight of beets. Pounds. | Weight of full stand in tons per acre. | Sugar in beet. | Purity. |
|----------------|---------------------------------|----------------------------------|----------------------------------------|----------------|---------|
| 21 and 24..... | 4                               | 1.12                             | 36.6                                   | 17.58          | 80.6    |
| 22 and 25..... | 6                               | 1.01                             | 22.0                                   | 17.67          | 79.9    |
| 23 and 26..... | 8                               | 1.21                             | 19.8                                   | 18.34          | 80.3    |

The beets at 8 inches apart are a little heavier than the others, and this is about the only noticeable difference. The generally accepted belief is that these beets at 8 inches apart should be poorer in quality than those growing closer together. In this particular case they are a little better. The most noticeable result is the computation on a full stand. If a field had a complete stand of beets four inches apart and of the same size as these, it would yield 36.6 tons of beets. While, at 6 inches apart, the yield would fall to 22.0 tons, and at 8 inches, to 19.8 tons. Judged in this way, the results are favorable to the thicker stand.

Lastly, a third test of the same point was tried with rows 27 and 30, that had been intended to be thinned to four inches apart, by selecting from the two rows twelve beets 4 inches apart on each side, another twelve beets from the same rows 6 inches apart, and a third twelve beets from the same rows 8 inches apart :



| Row.           | Distance<br>apart of beets.<br>Inches. | Average<br>weight of<br>beets.<br>Pounds. | Weight<br>of full stand.<br>in tons<br>per acre. | Sugar<br>in beet. | Purity. |
|----------------|----------------------------------------|-------------------------------------------|--------------------------------------------------|-------------------|---------|
| 27 and 30..... | 4                                      | 0.73                                      | 24.0                                             | 17.71             | 76.8    |
| 27 and 30..... | 6                                      | 0.89                                      | 19.5                                             | 17.10             | 81.2    |
| 27 and 30..... | 8                                      | 1.08                                      | 17.8                                             | 18.15             | 80.7    |

The differences in weight, owing to the different amount of space occupied by each beet, is quite noticeable, but the beets having the most room do not grow correspondingly larger in size, *i. e.*, the beets eight inches apart are not twice as large as those four inches apart, hence the weight of crop per acre is again in favor of the closer stand. The differences in the analyses are not great, but, here again, the larger beets test slightly better than the smaller beets.

Combining the five sets of tests, it can be said that, as a whole, they show that the distances apart of the beets, from four inches to ten inches, has but slight influence on the quality of the crop as to sugar and purity. It can also be said that it has some effect on the weight of the crop, and, if the stands are equal, more tons per acre will be raised at less than eight inches apart than at over this distance. Even this latter statement can be given as only a general tendency, liable to many exceptions. Rows 57-92 were sown under as nearly as possible like conditions, were all thinned by the same person at nearly the same time, and the thinning was intended to be to six inches. As a fact, the rows vary from an average distance of four inches between the beets to more than eight inches. If, now, there are selected the four rows with the greatest number of beets and the four rows with the least, the following results are obtained: The crop from four rows, 708 feet long, with 1,711 beets, or an average of five inches apart, weighed 1,199 pounds; the other four rows of the same length, with 1,137 beets, or eight inches apart, yielded 1,191 pounds. So that, in this case, the beets grew in size exactly proportional to the space they occupied.

To get still further light on the question of the relation of size and quality, a test was made with row 53. The whole row was dug and the six largest beets selected, also six of medium size and the six smallest.

| SIZE.         | Average<br>weight of<br>beets.<br>Pounds. | Total solids<br>in<br>juice. | Sugar<br>in beet. | Purity. |
|---------------|-------------------------------------------|------------------------------|-------------------|---------|
| Largest.....  | 1.73                                      | 21.87                        | 16.34             | 78.6    |
| Medium .....  | 0.85                                      | 23.27                        | 17.33             | 78.8    |
| Smallest..... | 0.30                                      | 24.53                        | 19.15             | 82.5    |

The above results show that in these extreme cases, the smaller the beets the better the sugar and purity. Even here, however, the difference is not large, being, in both cases, about one per cent of sugar for doubling the size of the beet. The previous tests seem to indicate that, for sizes from three-quarters of a pound to a pound and a half, the size of the beet has but little influence on its quality.

### 9. DIFFERENT DATES OF THINNING.

Most rules for the culture of sugar beets say that the thinning should be done as early as possible. Four tests were made to note the effects on the quantity and quality of the crop of thinning at different dates. The earliest thinning was done when the plants were quite young, from 18 to 26 days after planting, while the last thinning was 29 to 40 days after planting. These are not very wide extremes, but they cover the time at which most of the thinning would be done in beets raised for a factory.

| No. of Test.  | Date of thinning. | Days from planting to thinning. | Number of beets per row. | Weight of crop in tons per acre. | Sugar in beet. | Purity. |
|---------------|-------------------|---------------------------------|--------------------------|----------------------------------|----------------|---------|
| 1.....        | June 6            | 26                              | 260                      | 16.7                             | 15.90          | 77.4    |
| 2.....        | " 6               | 26                              | 363                      | 19.0                             | 17.54          | 83.1    |
| 3.....        | " 8               | 26                              | 385                      | 17.4                             | 17.22          | 81.0    |
| 4.....        | " 14              | 18                              | 241                      | 17.1                             | 16.59          | 85.4    |
| Average ..... | .....             | 24                              | 312                      | 17.5                             | 16.82          | 81.7    |
| 1.....        | June 16           | 36                              | 297                      | 17.0                             | 16.77          | 81.8    |
| 2.....        | " 16              | 36                              | 283                      | 17.3                             | 17.08          | 83.5    |
| 3.....        | " 16              | 34                              | 283                      | 16.4                             | .....          | .....   |
| 4.....        | " 17              | 21                              | 270                      | 20.3                             | 15.76          | 75.0    |
| Average.....  | .....             | 32                              | 283                      | 17.7                             | 16.54          | 80.1    |
| 1.....        | June 20           | 40                              | 268                      | 16.8                             | 17.22          | 85.3    |
| 2.....        | " 20              | 40                              | 305                      | 17.7                             | 18.43          | 85.1    |
| 3.....        | " 20              | 38                              | 327                      | 15.5                             | 16.00          | 78.0    |
| 4.....        | " 25              | 29                              | 288                      | 18.7                             | 17.31          | 81.6    |
| Average ..... | .....             | 37                              | 297                      | 17.2                             | 17.24          | 82.5    |

The average results are closely alike for the different dates, and the individual records are so irregular as to indicate that these different dates of thinning had little or no effect on either the quantity or the quality of the crop.

As all the results are excellent, the tests would seem to show that the work of thinning can be extended over a period of at least two weeks without injury to the crop. As one person can thin an



acre of beets in about four days, it follows that a given planting can be thinned at the rate of one person to each three or four acres.

## 10. VARIETY TESTS.

During the spring of 1898, the Station received from the U. S. Department of Agriculture, the seed of six varieties of sugar beets, with the request that they be given special tests. Two rows of each variety were sown, but, although the seed was sown at the rate of more than forty pounds of seed per acre, the stand was not so good as was gotten with the bulk of our beets. The seed of these six varieties was sown May 20, with a hand drill, in rows 18 inches apart, two rows of each kind, 177 feet long. The plants were thinned June 9 to nine inches apart, and the attempt was made to fill in the vacancies by transplanting, but nearly all of the transplanted beets died.

The first samples for testing were taken October 1, and the second samples October 22. The rest of the beets were dug October 26. The figures of analyses in the following table are the actual analytical results obtained on the beets three days after they were dug, with no allowance for drying out. During these three days, the beets had dried out about one-twenty-fifth of their weight. The beets were planted in the following order :

1. Zeringer, grown by Strandes.
2. Vilmorin's Improved, grown in Russia.
3. Kleinwanzlebener, grown by Vilmorin.
4. Pitschke's Elite.
5. Vilmorin's French, very rich.
6. Schreiber's Elite.

In the following table there has been added by way of comparison :

7. Average of eighteen rows of Kleinwanzlebener beets sown May 13 on the west side of the above varieties.

8. Average of fifteen rows of Kleinwanzlebener beets, sown May 27 on their east side. These last two were sown in rows 24 inches apart, and the intention was to thin them to six inches in the row.

| Variety. | Per cent of full stand. | Average distance apart in row Inches. | Average weight per beet. Pounds. | Crop in tons per acre. |
|----------|-------------------------|---------------------------------------|----------------------------------|------------------------|
| 1.....   | 24                      | 38                                    | 1.30                             | 11.7                   |
| 2.....   | 60                      | 15                                    | 1.16                             | 13.3                   |
| 3.....   | 46                      | 20                                    | 1.91                             | 16.8                   |
| 4.....   | 30                      | 30                                    | 1.71                             | 9.4                    |
| 5.....   | 32                      | 27                                    | 2.09                             | 13.2                   |
| 6.....   | 32                      | 26                                    | 2.13                             | 14.7                   |
| 7.....   | 83                      | 7                                     | 0.90                             | 16.3                   |
| 8.....   | 72                      | 8                                     | 1.09                             | 17.4                   |

| Variety.     | TEST OF OCTOBER 1. |         | TEST OF OCTOBER 22. |         | AVERAGE.       |         |
|--------------|--------------------|---------|---------------------|---------|----------------|---------|
|              | Sugar in beet.     | Purity. | Sugar in beet.      | Purity. | Sugar in beet. | Purity. |
| 1.....       | 14.73              | 73.4    | 15.44               | 76.9    | 15.08          | 76.6    |
| 2.....       | 16.48              | 84.9    | 16.96               | 79.0    | 16.72          | 81.9    |
| 3.....       | 14.82              | 78.9    | 15.68               | 77.7    | 15.25          | 78.3    |
| 4.....       | 17.20              | 87.1    | 17.20               | 76.3    | 17.20          | 81.7    |
| 5.....       | 15.49              | 80.4    | 14.73               | 77.6    | 15.11          | 79.0    |
| 6.....       | 16.15              | 80.3    | 15.06               | 76.7    | 15.60          | 78.5    |
| 7.....       | 15.54              | 74.3    | 17.80               | 78.8    | 16.67          | 76.5    |
| 8.....       | 16.50              | 79.9    | 16.87               | 77.4    | 16.68          | 78.6    |
| Average..... | 15.85              | 80.3    | 16.22               | 77.5    | 16.04          | 78.9    |

It will be noticed that the principal difference in the analyses of the two sets of samples is in the purity. The sugar in the beet improves about half a per cent, while the purity decreases nearly three per cent. The average analysis of these six varieties is almost exactly the same as of the Kleinwanzlebener beets we raised for our other tests on both sides of them.

Tests of several other varieties were made on the College farm in connection with the general test of European as compared with American grown seed. The results will be reported with the figures obtained on the same test throughout the state.

## 11. NUMBER OF IRRIGATIONS.

A plot of beets at the Rocky Ford substation was divided into three sections; the first received no irrigation during the season; the second was irrigated once, while the third was given four irrigations. The results are given in the following table:



| Number of Irrigations. | Weight of crop in tons per acre. | Sugar in beet. | Purity. | Pure sugar per acre. Pounds. |
|------------------------|----------------------------------|----------------|---------|------------------------------|
| None .....             | 12.0                             | 15.68          | 79.5    | 3763                         |
| One.....               | 12.4                             | 17.58          | 85.1    | 4395                         |
| Four.....              | 11.9                             | 15.53          | 78.7    | 3696                         |

The results are somewhat different from those expected when the experiment was planned. They are to be explained by the fact that the unusually heavy rains of the season were almost enough to raise beets in that locality without any irrigation. The one irrigation gave the beets all the water they needed and the other three irrigations were a positive detriment.

In connection with the tests of seed from different sources, Mr. C. K. McHarg, of Pueblo, made for us some tests in regard to late irrigation.

All of the plot, containing three-fourths of an acre, was treated alike until the latter part of the season, then one-half received no further irrigation, while the other half was given two irrigations additional.

The crop was weighed for each variety separately and yielded the following results :

| Variety.                        | Weight of crop from half not irrigated after August 20. Pounds. | Weight of crop from half irrigated twice after August 20. Pounds. |
|---------------------------------|-----------------------------------------------------------------|-------------------------------------------------------------------|
| Original Kleinwanzlebener ..... | 1018                                                            | 1133                                                              |
| Utah Kleinwanzlebener .....     | 1069                                                            | 1125                                                              |
| Eddy Kleinwanzlebener .....     | 787                                                             | 927                                                               |
| Elite Kleinwanzlebener.....     | 964                                                             | 1111                                                              |
| Vilmorin.....                   | 885                                                             | 931                                                               |
| Mangold .....                   | 694                                                             | 1041                                                              |
| Total .....                     | 5417                                                            | 6268                                                              |

In this case there was a gain of one-seventh in the weight of the crop by irrigations late in the season.

An average sample of the Original Kleinwanzlebener from the part receiving the extra irrigations tested 16.42 sugar in beet and 81.0 purity, while a sample from the other half tested 15.79 sugar and 81.7 purity. Here there was an advantage in both quantity and quality from the late irrigation.

## AMERICAN-GROWN SUGAR BEET SEED COMPARED WITH THAT GROWN IN EUROPE.

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An extensive series of tests was made of beet seed grown in the United States as compared with seed grown in Europe. Six varieties were used; one grown in France, one in Saxony, two in Germany, and two in the United States. The sources of the seed are as follows:

1. *Utah Kleinwanzlebener*.—This seed was grown at Lehi, Utah, by the Utah Sugar Company. The seed first used was the Original Kleinwanzlebener from Germany, and the seed tested this year was the second generation of American seed grown from the German seed.

2. *Original Kleinwanzlebener*.—Imported from Germany and sent to us by the Utah Sugar Company. Of course this is not the identical seed that was used as the ancestor of the Utah Kleinwanzlebener seed above mentioned, but it is from the same seed farm, of a crop a few years later and is presumably of about the same quality.

3. *Vilmorin*.—Sent us by the United States Department of Agriculture and imported by them from the original growers in France.

4. *Mangold*.—Grown by M. Knauer, Grœbers, Saxony, and imported for us by the agent, H. Cordes, LaGrande, Oregon.

5. *Eddy Kleinwanzlebener*.—This seed was grown at Eddy, New Mexico, during the season of 1897 from the beets of 1896 that were grown from seed obtained from Maison Carlier, Orchies, North France. It is, therefore, the first generation of American seed from the original French seed. This is the first crop of seed raised at Eddy.

6. *Elite Kleinwanzlebener*.—Imported from Germany by the United States Department of Agriculture.

Seed of these six varieties was sent to quite a number of persons in the various irrigated portions of Colorado, who had promised to take special pains in the test. Some of the tests were to be on a small scale with the richest of ground and the best of conditions. Another set of tests was to be on a larger scale under general farm conditions.

Great credit is due the experimenters for the large amount of labor and painstaking care that were bestowed on these tests. The first samples were taken the last week in September, being the Utah Kleinwanzlebener and the Original Kleinwanzlebener. Two weeks



later samples were requested of the Vilmorin and Mangold, and the next week the growers were asked to send samples of the other two varieties. About the first of November instructions were sent to harvest the crops and send samples of all six varieties.

Here are therefore two sets of samples, one set in three pairs and the other set from ripe crops in which the samples of the six varieties were taken at the same time and under the same conditions.

The earlier samples are all from the larger plots under field conditions. The later samples are given from the two plots separately.

UTAH KLEINWANZLEBENER.

| Name.                 | Place.           | Date of taking sample. | Width between rows. Ins. | Average distance apart of beets in row. Ins. | Average wght of beets. Lbs. | Crop per acre. Tons. | Sugar in beet. | Purity. |
|-----------------------|------------------|------------------------|--------------------------|----------------------------------------------|-----------------------------|----------------------|----------------|---------|
| S. M. Scott.....      | Fort Morgan....  | Sept. 14               | 30                       | 11.3                                         | 0.75                        | 6.5                  | 15.55          | 73.1    |
| S. S. Abbott .....    | Canfield .....   | " 14                   | 18                       | 9.6                                          | 1.12                        | 22.5                 | 16.00          | 80.0    |
| J. A. Davis .....     | Berthoud.....    | " 15                   | 24                       | 9.8                                          | 1.62                        | 26.8                 | 14.71          | 80.4    |
| J. D. Payne.....      | Grand Junction.. | " 15                   | 18                       | 9.1                                          | 3.25                        | 26.6                 | 9.09           | 64.6    |
| C. K. McHarg.....     | Pueblo . ....    | " 17                   | 24                       | 8.9                                          | 0.72                        | 10.6                 | 12.80          | 76.5    |
| M. D. Parmenter ..... | Lamar.....       | " 15                   | 18                       | 6.7                                          | 1.10                        | 28.0                 | 14.71          | 78.3    |
| Adam May .....        | Debeque.....     | " 17                   | 18                       | 8.4                                          | 1.12                        | 23.5                 | 15.22          | 82.3    |
| F. M. Wright.....     | Berthoud.....    | " 19                   | 18                       | 25.7                                         | 1.00                        | 7.0                  | 12.80          | 70.3    |
| E. K. Smith .....     | Fort Lupton....  | " 22                   | 18                       | ...                                          | .....                       | .....                | 20.10          | 91.1    |
| J. W. Dove .....      | Alamosa .....    | " 23                   | 18                       | 10.3                                         | 1.06                        | 18.1                 | 12.38          | 81.1    |
| J. W. Douthitt. ....  | Montrose.....    | Oct. 3                 | 18                       | 6.0                                          | 1.06                        | 30.8                 | 15.60          | 81.9    |
| Average.....          | .....            | Sept. 18               | 20                       | 10.8                                         | 1.28                        | 20.1                 | 14.09          | 78.1    |

ORIGINAL KLEINWANZLEBENER.

|                       |                  |         |    |       |       |       |       |      |
|-----------------------|------------------|---------|----|-------|-------|-------|-------|------|
| S. M. Scott.....      | Fort Morgan....  | Sept 14 | 30 | 11.1  | 0.62  | 5.4   | 14.82 | 69.3 |
| S. S. Abbott.....     | Canfield .....   | " 14    | 18 | 9.6   | 1.00  | 18.2  | 14.09 | 78.5 |
| J. A. Davis.....      | Berthoud.....    | " 15    | 24 | 10.3  | 2.00  | 25.4  | 13.89 | 79.5 |
| J. D. Payne.....      | Grand Junction.. | " 15    | 18 | 8.9   | 2.37  | 46.5  | 11.83 | 71.3 |
| C. K. McHarg.....     | Pueblo.....      | " 17    | 24 | 11.1  | 0.60  | 7.2   | 16.74 | 83.0 |
| M. D. Parmenter ..... | Lamar. ....      | " 15    | 8  | 6.9   | 0.81  | 17.4  | 13.20 | 79.8 |
| Adam May .....        | Debeque.....     | " 17    | 18 | 8.5   | 1.75  | 35.8  | 13.02 | 73.7 |
| F. M. Wright .....    | Berthoud.....    | " 19    | 18 | 25.7  | 0.75  | 5.4   | 10.72 | 63.3 |
| E. K. Smith.....      | Fort Lupton....  | " 22    | 18 | ..... | ..... | ..... | 15.04 | 76.1 |
| J. W. Dove.....       | Alamosa .....    | " 23    | 18 | 9.4   | 0.75  | 14.3  | 11.81 | 77.6 |
| J. W. Douthitt.....   | Montrose.....    | Oct. 3  | 18 | 7.2   | 1.25  | 30.7  | 16.13 | 85.0 |
| Average.....          | .....            | Sept 18 | 20 | 10.9  | 1.19  | 20.6  | 13.75 | 75.3 |

VILMORIN.

| Name.                 | Place.           | Date of taking sample. | Wdth between rows. Ins. | Average distance apart of beets in row. Ins. | Average wght of beets. Lbs. | Crop per acre. Tons. | Sugar in beet. | Purity. |
|-----------------------|------------------|------------------------|-------------------------|----------------------------------------------|-----------------------------|----------------------|----------------|---------|
| S. M. Scott.....      | Fort Morgan....  | Oct. 25                | 30                      | 13.6                                         | 0.95                        | 7.2                  | 16.44          | 87.7    |
| S. S. Abbott.....     | Canfield .....   | " 13                   | 18                      | 9.2                                          | 1.45                        | 27.2                 | 16.44          | .....   |
| J. A. Davis.....      | Berthoud.....    | " 14                   | 24                      | 15.6                                         | 1.42                        | 11.4                 | 15.48          | 81.0    |
| J. D. Payne .....     | Grand Junction.. | " 17                   | 18                      | 7.6                                          | 1.15                        | 28.9                 | 17.05          | 78.6    |
| C. K. McHarg.....     | Pueblo.....      | " 18                   | 22                      | 13.2                                         | 0.84                        | 9.2                  | 17.38          | .....   |
| M. D. Parmenter ..... | Lamar.....       | " 13                   | 18                      | 12.4                                         | 1.54                        | 21.7                 | 16.67          | 88.6    |
| Adam May .....        | Debeque.....     | " 18                   | 18                      | 10.0                                         | 1.40                        | 24.5                 | 16.87          | 72.5    |
| F. M. Wright .....    | Berthoud.....    | " 25                   | 18                      | 24.0                                         | 1.37                        | 11.5                 | 16 15          | 81.3    |
| E. K. Smith.....      | Fort Lupton....  | " 12                   | 18                      | 8.6                                          | 0.64                        | 13.1                 | 17 42          | .....   |
| J. W. Dove .....      | Alamosa .....    | " 17                   | 18                      | 8.0                                          | 0.87                        | 20.0                 | 11.80          | 78.5    |
| J. W. Douthitt.....   | Montrose.....    | " 24                   | 18                      | 4.8                                          | 0.68                        | 21.4                 | 18.22          | 88.3    |
| Average.....          | .....            | Oct. 18                | 20                      | 11.5                                         | 1.12                        | 17.8                 | 16.30          | 82.1    |

MANGOLD.

|                      |                  |         |    |      |      |      |       |       |
|----------------------|------------------|---------|----|------|------|------|-------|-------|
| S. M. Scott .....    | Fort Morgan....  | Oct. 25 | 30 | 9.8  | 1.39 | 14.6 | 13.06 | 73.8  |
| S. S. Abbott.....    | Canfield .....   | " 13    | 18 | 9.2  | 1.52 | 29.0 | 16.39 | 78.0  |
| J. A. Davis ...      | Berthoud... ..   | " 14    | 24 | 15.2 | 1.57 | 13.5 | 12.58 | 74.2  |
| J. D. Payne...       | Grand Junction.. | " 17    | 18 | 8.0  | 1.50 | 32.7 | 13.82 | 83.5  |
| C. K. McHarg.....    | Pueblo.....      | " 18    | 22 | 15.2 | 1.02 | 10.0 | 17.42 | ..... |
| M. D. Parmenter..... | Lamar... ..      | " 13    | 18 | 13.2 | 1.75 | 23.1 | 16.70 | 87.4  |
| Adam May .....       | Debeque.....     | " 18    | 18 | 8.8  | 1.44 | 28.0 | 13.69 | 67.2  |
| F. M. Wright.....    | Berthoud.....    | " 25    | 18 | 24.0 | 0.65 | 5.0  | 18.05 | 84.5  |
| E. K. Smith .....    | Fort Lupton....  | " 12    | 18 | 8.8  | 0.77 | 14.6 | 16.06 | 90.9  |
| J. W. Dove.....      | Alamosa .....    | " 17    | 18 | 7.2  | 1.12 | 27.2 | 10.86 | 77.8  |
| J. W. Douthitt.....  | Montrose.....    | " 24    | 18 | 5.2  | 0.69 | 23.1 | 16.04 | 83.7  |
| Average.....         | .....            | Oct. 18 | 20 | 11.3 | 1.22 | 20.1 | 14.97 | 80.1  |



EDDY KLEINWANZLEBENER.

| Name.              | Place.               | Date of<br>taking<br>sam-<br>ple. | Wdth<br>be-<br>twe'n<br>rows.<br>Ins. | Aver-<br>age<br>dis-<br>tance<br>apart<br>of<br>beets<br>in<br>row.<br>Ins. | Aver-<br>age<br>wght<br>of<br>beets.<br>Lbs. | Crop<br>per<br>acre<br>Tons. | Sugar<br>in<br>beet. | Pur-<br>ity. |
|--------------------|----------------------|-----------------------------------|---------------------------------------|-----------------------------------------------------------------------------|----------------------------------------------|------------------------------|----------------------|--------------|
| S. S. Abbott.....  | ..... Canfield ..... | Oct. 29                           | 18                                    | 7.6                                                                         | 1.00                                         | 23.1                         | 14.26                | 78.1         |
| C. K. McHarg ..... | ..... Pueblo.....    | Nov. 2                            | 24                                    | 10.4                                                                        | 0.94                                         | 12.0                         | 17.09                | 81.6         |
| F. M. Wright ..... | ..... Berthoud.. ... | Oct. 31                           | 18                                    | .....                                                                       | 1.35                                         | .....                        | 13.03                | 73.7         |
| J. W. Dove.....    | ..... Alamosa .....  | Nov. 1                            | 18                                    | 7.2                                                                         | 0.62                                         | 24.5                         | 12.70                | 83.3         |
| Adam May .....     | ..... Debeque .....  | " 14                              | 18                                    | .....                                                                       | 1.30                                         | .....                        | 16.39                | 85.8         |
| J. D. Payne .....  | ..Grand Junction..   | " 7                               | 18                                    | 11.7                                                                        | 1.61                                         | 26.7                         | 14.82                | 77.9         |
| Average .....      | .....                | Nov. 4                            | 19                                    | 9.2                                                                         | 1.15                                         | 21.6                         | 14.71                | 80.0         |

ELITE KLEINWANZLEBENER.

|                    |                      |         |    |       |      |       |       |      |
|--------------------|----------------------|---------|----|-------|------|-------|-------|------|
| S. S. Abbott.....  | ..... Canfield ..... | Oct 29  | 18 | 9.3   | 1.25 | 23.6  | 16.35 | 81.1 |
| C. K. McHarg ..... | ..... Pueblo.....    | Nov. 2  | 24 | 8.0   | 0.88 | 14.4  | 18.49 | 89.1 |
| F. M. Wright.....  | ..... Berthoud.....  | Oct. 31 | 18 | ..... | 1.25 | ..... | 14.43 | 73.7 |
| J. W. Dove.....    | ..... Alamosa .....  | Nov. 1  | 18 | 8.0   | 1.12 | 24.5  | 9.37  | 69.7 |
| Adam May.....      | ..... Debeque .....  | " 14    | 18 | ..... | 1.30 | ..... | 16.39 | 82.3 |
| J. D. Payne.....   | ...Grand Junction..  | " 7     | 18 | 11.7  | 1.61 | 23.4  | 14.58 | 79.0 |
| Average.....       | .....                | Nov. 4  | 19 | 9.2   | 1.23 | 21.5  | 14.93 | 79.1 |

AVERAGES.

|                                |          |    |      |      |      |       |      |
|--------------------------------|----------|----|------|------|------|-------|------|
| Utah Kleinwanzlebener.....     | Sept. 18 | 20 | 10.8 | 1.28 | 20.1 | 14.09 | 78.1 |
| Original Kleinwanzlebener..... | " 18     | 20 | 10.9 | 1.19 | 20.6 | 13.75 | 75.3 |
| Vilmorin.....                  | Oct. 18  | 20 | 11.5 | 1.12 | 17.8 | 16.30 | 82.1 |
| Mangold.....                   | " 18     | 20 | 11.3 | 1.22 | 20.1 | 14.97 | 80.1 |
| Eddy Kleinwanzlebener.....     | Nov. 4   | 19 | 9.2  | 1.15 | 21.6 | 14.71 | 80.0 |
| Elite Kleinwanzlebener.....    | " 4      | 19 | 9.2  | 1.23 | 21.5 | 14.93 | 79.1 |

# RIPE CROPS.

## UTAH KLEINWANZLEBENER.

| Name.                  | Place.               | Date when crop was harvested. | Average distance apart of beets in row. Inches. | Average weight of beets Lbs. | Crop per acre. Tons. | Sugar in beet. | Purity. |
|------------------------|----------------------|-------------------------------|-------------------------------------------------|------------------------------|----------------------|----------------|---------|
| <i>Small Plot.</i>     |                      |                               |                                                 |                              |                      |                |         |
| S. S. Abbott.....      | ..... Canfield ..... | Oct. 29                       | 9.4                                             | 1.05                         | 19.4                 | 16.26          | 83.8    |
| M. D. Parmenter .....  | ..... Lamar .....    | " 28                          | 7.1                                             | 1.15                         | 28.3                 | 14.08          | 82.1    |
| C. M. C. Woolman ..... | ..... Sterling ..... | " 31                          | 9.0                                             | 0.80                         | 16.1                 | 18.40          | 85.4    |
| C. M. Rulison.....     | .... Parachute ....  | Nov. 12                       | 5.3                                             | 1.36                         | 44.6                 | 16.91          | 81.9    |
| C. K. McHarg.....      | ..... Pueblo.....    | " 9                           | 7.1                                             | 1.32                         | 24.5                 | 14.80          | 80.0    |
| J. D. Payne.....       | ..Grand Junction..   | " 12                          | 9.2                                             | 5.10                         | 105.5                | 8.88           | 64.6    |
| Chas. Milne .....      | ..... La Jara .....  | " 7                           | 8.5                                             | 1.00                         | 20.6                 | 15.88          | 80.1    |
| J. W. Douthitt.....    | ..... Montrose.....  | " 8                           | 6.7                                             | 1.18                         | 31.2                 | 12.63          | 74.5    |
| Average.....           | .....                | Nov. 4                        | 7.6                                             | 1.12                         | 26.4                 | 15.57          | 81.0    |
| <i>Large Plot.</i>     |                      |                               |                                                 |                              |                      |                |         |
| M. D. Parmenter .....  | ..... Lamar .....    | Oct. 28                       | 9.6                                             | 1.11                         | 20.1                 | 16.00          | 87.8    |
| C. M. Rulison.....     | .... Parachute ....  | Nov. 12                       | 5.0                                             | 1.18                         | 41.8                 | 15.27          | 80.8    |
| Substation .....       | .... Focky Ford....  | Oct. 29                       | 7.4                                             | 0.67                         | 15.6                 | 17.55          | 84.6    |
| College Farm.....      | ... Fort Collins. .  | " 26                          | 12.4                                            | 1.16                         | 16.3                 | 17.87          | 82.8    |
| Average.....           | .....                | Nov. 1                        | 8.6                                             | 1.03                         | 23.4                 | 16.67          | 84.0    |

## ORIGINAL KLEINWANZLEBENER.

|                        |                      |         |      |      |       |       |      |
|------------------------|----------------------|---------|------|------|-------|-------|------|
| <i>Small Plot.</i>     |                      |         |      |      |       |       |      |
| S. S. Abbott.....      | ..... Canfield ..... | Oct. 29 | 9.6  | 0.85 | 15.5  | 14.89 | 78.6 |
| M. D. Parmenter.....   | ... .. Lamar .....   | " 28    | 9.6  | 2.18 | 39.9  | 12.46 | 76.6 |
| C. M. C. Woolman ..... | ..... Sterling ..... | " 31    | 9.0  | 0.87 | 18.0  | 16.57 | 76.9 |
| C. M. Rulison.....     | .... Parachute ....  | Nov. 12 | 5.0  | 1.13 | 41.8  | 17.10 | 86.3 |
| C. K. McHarg.....      | ..... Pueblo.....    | " 9     | 8.9  | 1.59 | 23.4  | 14.13 | 79.6 |
| J. D. Payne.....       | ..Grand Junction..   | " 12    | 9.6  | 6.00 | 123.4 | 8.93  | 66.3 |
| Chas. Milne .....      | ..... La Jara.....   | " 7     | 8.0  | 0.97 | 21.2  | 15.75 | 79.8 |
| J. W. Douthitt.....    | ..... Montrose.....  | " 8     | 6.7  | 1.62 | 42.1  | 13.11 | 72.4 |
| Average.....           | .....                | Nov. 5  | 8.1  | 1.32 | 28.8  | 14.86 | 77.7 |
| <i>Large Plot.</i>     |                      |         |      |      |       |       |      |
| M. D. Parmenter .....  | ..... Lamar .....    | Oct. 28 | 10.0 | 1.82 | 23.2  | 14.70 | 86.9 |
| C. M. Rulison.....     | .... Parachute ....  | Nov. 12 | 5.3  | 1.22 | 39.6  | 16.39 | 81.7 |
| Substation.....        | ... Rocky Ford ...   | Oct. 29 | 8.2  | 0.84 | 17.9  | 16.45 | 82.7 |
| College Farm.....      | ...Fort Collins...   | " 26    | 8.2  | 0.87 | 18.5  | 15.21 | 74.7 |
| Average.....           | .....                | Nov. 1  | 7.9  | 1.19 | 24.8  | 15.69 | 81.5 |



VILMORIN.

| Name.                  | Place.               | Date when crop was har-vested | Aver-<br>age<br>dis-<br>tance<br>apart<br>of beets<br>in row.<br>Inches. | Aver-<br>age<br>weight<br>of beets<br>Lbs. | Crop<br>per<br>acre.<br>Tons. | Sugar<br>in beet. | Pur-<br>ity. |
|------------------------|----------------------|-------------------------------|--------------------------------------------------------------------------|--------------------------------------------|-------------------------------|-------------------|--------------|
| <i>Small Plot.</i>     |                      |                               |                                                                          |                                            |                               |                   |              |
| S. S. Abbott.....      | ..... Canfield ..... | Oct. 29                       | 8.8                                                                      | 1.33                                       | 26.4                          | 16.79             | 87.3         |
| M. D. Parmenter .....  | ..... Lamar .....    | " 28                          | 7.0                                                                      | 1.13                                       | 28.3                          | 14.38             | 76.1         |
| C. M. C. Woolman ..... | ..... Sterling ..... | " 31                          | 9.0                                                                      | 0.94                                       | 18.0                          | 15.31             | 78.6         |
| C. M. Rulison.....     | .... Parachute ..... | Nov. 12                       | 5.2                                                                      | 1.10                                       | 37.2                          | 15.31             | 83.6         |
| C. K. McHarg.....      | ..... Pueblo.....    | " 9                           | 8.0                                                                      | 1.27                                       | 22.3                          | 14.42             | 78.3         |
| J. D. Payne .....      | ..Grand Junction..   | " 12                          | 9.0                                                                      | 4.46                                       | 90.2                          | 9.65              | 67.9         |
| Chas. Milne .....      | ..... La Jara ...    | " 7                           | 8.0                                                                      | 0.95                                       | 20.6                          | 13.48             | 76.5         |
| J. W. Douthitt.....    | ..... Montrose.....  | " 8                           | 6.7                                                                      | 1.06                                       | 27.7                          | 13.80             | 74.2         |
| Average.....           | .....                | Nov. 4                        | 7.5                                                                      | 1.11                                       | 25.8                          | 14.78             | 79.2         |
| <i>Large Plot.</i>     |                      |                               |                                                                          |                                            |                               |                   |              |
| M. D. Parmenter.....   | ..... Lamar .....    | Oct. 28                       | 16.0                                                                     | 1.82                                       | 14.4                          | 14.95             | 84.8         |
| C. M. Rulison.....     | .... Parachute ....  | Nov. 12                       | 6.0                                                                      | 1.12                                       | 38.5                          | 15.92             | 80.6         |
| Substation .....       | ... Rocky Ford ...   | Oct. 29                       | 7.0                                                                      | 0.50                                       | 12.5                          | 18.00             | 89.2         |
| College Farm .....     | ... Fort Collins ... | " 26                          | 10.9                                                                     | 0.92                                       | 14.7                          | 17.15             | 78.5         |
| Average.....           | .....                | Nov. 1                        | 10.0                                                                     | 1.09                                       | 20.0                          | 16.50             | 83.3         |

MANGOLD.

|                        |                      |         |      |      |      |       |      |
|------------------------|----------------------|---------|------|------|------|-------|------|
| <i>Small Plot.</i>     |                      |         |      |      |      |       |      |
| S. S. Abbott .....     | ..... Canfield ..... | Oct. 29 | 8.6  | 1.18 | 24.0 | 13.00 | 68.4 |
| M. D. Parmenter .....  | ..... Lamar .....    | " 28    | 6.7  | 1.32 | 34.5 | 13.42 | 80.6 |
| C. M. C. Woolman ..... | ..... Sterling ..... | " 31    | 9.0  | 0.78 | 15.5 | 14.43 | 74.9 |
| C. M. Rulison .....    | .... Parachute ....  | Nov. 12 | 5.8  | 1.27 | 38.2 | 14.66 | 78.3 |
| C. K. McHarg.....      | ..... Pueblo.....    | " 9     | 8.3  | 1.28 | 20.0 | 13.71 | 78.3 |
| J. D. Payne.....       | ..Grand Junction..   | " 12    | 9.0  | 4.00 | 81.1 | 9.11  | 65.5 |
| Chas. Milne .....      | ..... La Jara.....   | " 7     | 8.0  | 1.06 | 23.0 | 14.32 | 74.8 |
| J. W. Douthitt.....    | ..... Montrose.....  | " 8     | 6.7  | 1.60 | 41.4 | 13.44 | 71.0 |
| Average.....           | .....                | Nov. 4  | 7.4  | 1.21 | 28.1 | 14.00 | 75.2 |
| <i>Large Plot.</i>     |                      |         |      |      |      |       |      |
| M. D. Parmenter .....  | ..... Lamar .....    | Oct. 28 | 20.4 | 1.55 | 13.5 | 14.57 | 87.5 |
| C. M. Rulison.....     | .... Parachute ....  | Nov. 12 | 5.0  | 1.18 | 42.3 | 15.88 | 82.7 |
| Substation .....       | ... Rocky Ford ...   | Oct. 29 | 10.4 | 1.00 | 16.7 | 15.84 | 82.7 |
| College Farm.....      | ... Fort Collins ..  | " 26    | 9.4  | 1.04 | 19.2 | 17.15 | 78.0 |
| Average.....           | .....                | Nov. 1  | 11.3 | 1.19 | 22.9 | 15.86 | 82.7 |

EDDY KLEINWANZLEBENER.

| Name.                  | Place.               | Date when crop was harvested. | Average distance apart of beets in row. Inches. | Average weight of beets. Lbs. | Crop per acre. Tons. | Sugar in beet. | Purity. |
|------------------------|----------------------|-------------------------------|-------------------------------------------------|-------------------------------|----------------------|----------------|---------|
| <i>Small Plot.</i>     |                      |                               |                                                 |                               |                      |                |         |
| S. S. Abbott.....      | ..... Canfield.....  | Oct. 29                       | 8.0                                             | 1.04                          | 22.0                 | .....          | .....   |
| M. D. Parmenter.....   | ..... Lamar .....    | " 28                          | 6.7                                             | 1.67                          | 43.6                 | 13.56          | 81.8    |
| C. M. C. Woolman ..... | ..... Sterling ..... | " 31                          | 9.0                                             | 0.94                          | 19.1                 | 16.76          | 82.9    |
| C. M. Rulison.....     | .....,Parachute..... | Nov. 12                       | 5.6                                             | 1.12                          | 34.4                 | 16.04          | 84.8    |
| C. K. McHarg.....      | ..... Pueblo.....    | " 9                           | 8.0                                             | 1.60                          | 26.1                 | 13.39          | 75.7    |
| J. D. Payue ....       | ..Grand Junction..   | " 12                          | 9.2                                             | 5.00                          | 98.5                 | 10.36          | 69.5    |
| Chas. Milne .....      | ..... La Jara.....   | " 7                           | 7.3                                             | 1.00                          | 23.0                 | 15.80          | 81.7    |
| J. W. Douthitt.....    | .....Montrose.....   | " 8                           | 6.7                                             | 1.22                          | 31.0                 | 12.70          | 70.8    |
| Average.....           | .....                | Nov. 4                        | 7.3                                             | 1.25                          | 27.0                 | 14.71          | 79.4    |
| <i>Large Plot.</i>     |                      |                               |                                                 |                               |                      |                |         |
| M. D. Parmenter.....   | ..... Lamar .....    | Oct. 28                       | 10.8                                            | 0.95                          | 15.5                 | 14.22          | 81.8    |
| C. M. Rulison ....     | .... Parachute ....  | Nov. 12                       | 5.1                                             | 1.18                          | 39.6                 | 16.50          | 83.3    |
| Substation....         | ... Rocky Ford ...   | Oct. 29                       | 8.4                                             | 0.70                          | 14.4                 | 16.82          | 87.5    |
| College Farm.....      | ...Fort Collins...   | " 26                          | 11.1                                            | 1.06                          | 16.5                 | 15.80          | 78.1    |
| Average.....           | .....                | Nov. 1                        | 8.6                                             | 0.97                          | 21.5                 | 15.83          | 82.7    |

ELITE KLEINWANZLEBENER.

|                       |                      |         |       |       |       |       |       |
|-----------------------|----------------------|---------|-------|-------|-------|-------|-------|
| <i>Small Plot.</i>    |                      |         |       |       |       |       |       |
| S. S. Abbott .....    | ..... Canfield ..... | Oct. 29 | 8.0   | 1.00  | 21.8  | 15.90 | 78.5  |
| M. D. Parmenter.....  | ..... Lamar .....    | " 28    | 6.7   | 1.60  | 40.4  | 15.75 | 84.0  |
| C. M. C. Woolman..... | ..... Sterling ..... | " 31    | 9.0   | 0.92  | 19.2  | 17.23 | 83.4  |
| C. M. Rulison.....    | .... Parachute ....  | Nov. 12 | 6.0   | 1.36  | 40.9  | 16.84 | 85.3  |
| C. K. McHarg.....     | ..... Pueblo.....    | " 9     | 7.7   | 1.50  | 25.6  | 15.38 | 80.0  |
| J. D. Payne.....      | ..Grand Junction .   | " 12    | 9.0   | 5.00  | 102.2 | 10.45 | 70.6  |
| Chas. Milne.....      | ..... La Jara.....   | " 7     | 8.0   | 1.11  | 24.2  | 15.50 | 85.7  |
| J. W. Douthitt.....   | .....Montrose.....   | " 8     | 6.7   | 1.22  | 31.9  | 15.08 | 77.0  |
| Average.....          | .....                | Nov. 4  | 7.4   | 1.24  | 29.1  | 15.95 | 82.0  |
| <i>Large Plot.</i>    |                      |         |       |       |       |       |       |
| M. D. Parmenter.....  | ..... Lamar .....    | Oct. 28 | 12.8  | 0.82  | 10.9  | 16.61 | 85.6  |
| C. M. Rulison.....    | .... Parachute ....  | Nov. 12 | 4.9   | 1.14  | 40.7  | 15.42 | 84.2  |
| Substation .....      | ....Rocky Ford....   | Oct. 29 | 6.8   | 0.67  | 17.3  | 17.38 | 86.1  |
| College Farm.....     | ... Fort Collins...  | .....   | ..... | ..... | ..... | ..... | ..... |
| Average.....          | .....                | Nov. 1  | 8.2   | 0.88  | 23.0  | 16.47 | 85.3  |



AVERAGES.

| Variety.                       | Plot. | Crop per<br>acre.<br>Tons. | Sugar in<br>beet. | Purity. |
|--------------------------------|-------|----------------------------|-------------------|---------|
| Utah Kleinwanzlebener.....     | Small | 26.4                       | 15.57             | 81.0    |
|                                | Large | 23.4                       | 16.67             | 84.0    |
| Original Kleinwanzlebener..... | Small | 28.8                       | 14.86             | 77.7    |
|                                | Large | 24.8                       | 15.69             | 81.5    |
| Vilmorin.....                  | Small | 25.8                       | 14.78             | 79.2    |
|                                | Large | 20.0                       | 16.50             | 83.3    |
| Mangold .....                  | Small | 28.1                       | 14.00             | 75.2    |
|                                | Large | 22.9                       | 15.86             | 82.7    |
| Eddy Kleinwanzlebener .....    | Small | 27.0                       | 14.71             | 79.4    |
|                                | Large | 21.5                       | 15.83             | 82.7    |
| Elite Kleinwanzlebener....     | Small | 29.1                       | 15.95             | 82.0    |
|                                | Large | 23.0                       | 16.47             | 85.3    |
| Utah Kleinwanzlebener .....    | Both. | 24.9                       | 16.12             | 82.5    |
| Original Kleinwanzlebener..... | "     | 26.8                       | 15.27             | 79.6    |
| Vilmorin.....                  | "     | 22.9                       | 15.64             | 81.2    |
| Mangold .....                  | "     | 25.5                       | 14.93             | 78.9    |
| Eddy Kleinwanzlebener .....    | "     | 24.2                       | 15.27             | 81.0    |
| Elite Kleinwanzlebener .....   | "     | 26.0                       | 16.21             | 83.6    |
| Average .....                  | ..... | 25.1                       | 15.57             | 81.3    |

| Variety.                       | Per cent of<br>perfect<br>stand.<br>Weight. | Average<br>weight of<br>beets.<br>Pounds. | Pure sugar<br>per acre.<br>Pounds. | Available<br>sugar per<br>acre.<br>Pounds. |
|--------------------------------|---------------------------------------------|-------------------------------------------|------------------------------------|--------------------------------------------|
| Utah Kleinwanz ebener.....     | 86                                          | 1.07                                      | 8060                               | 6650                                       |
| Original Kleinwanzlebener..... | 87                                          | 1.25                                      | 8184                               | 6514                                       |
| Vilmorin.....                  | 80                                          | 1.10                                      | 7163                               | 5816                                       |
| Mangold .....                  | 75                                          | 1.20                                      | 7650                               | 6036                                       |
| Eddy Kleinwanzlebener.....     | 88                                          | 1.11                                      | 7390                               | 5986                                       |
| Elite Kleinwanzlebener .....   | 89                                          | 1.06                                      | 8429                               | 7047                                       |
| Average .....                  | 84                                          | 1.13                                      | 7813                               | 6341                                       |

A comparison of the results from the different kinds of seed shows, first of all, that they are all good seeds. An average of 25.1 tons of beets per acre testing 15.57 sugar and 81.3 purity is a very high yield. There is, however, considerable difference in the results from the different varieties. The Elite Kleinwanzlebener and the Vilmorin were sent us by the United States Department of Agriculture as the best beet seed that they could get. The Original Kleinwanzlebener was selected by the Utah Sugar company as in their judgment the best brand of seed on the market from which to raise their own seed. If we take the average of these three first-class seeds and compare it with the seed raised in Utah, the comparison is in favor of the Utah-grown seed in per cent of sugar and purity, while the crop per acre is equal. The Utah seed is, therefore, superior in pure sugar per acre and in available sugar per acre. The Utah seed is superior to the seed from which it is descended in sugar and purity, but a little inferior in quantity of crop.

The seed grown at Eddy does not give so good results as the Utah seed, but it equals the Vilmorin and is not far behind the Original Kleinwanzlebener. The germinating quality of the seeds is quite satisfactory. The four Kleinwanzlebener varieties give 87 per cent of stand, while the Vilmorin gives 80 per cent, and the Mangold 75 per cent.

In the light of these experiments there can be no doubt that sugar beet seed can be grown in the United States fully equal to the best of the imported seed.

The tables of the yield of the small plots include the figures from the field of Mr. J. D. Payne, of Grand Junction, but these figures are not used in making the averages, because they are so different from those of the other experimenters and so different from the average of Colorado results.

Mr. Payne planted his beets in a deep sandy loam, where the roots had unlimited room to grow downward. The soil below was full of water that was constantly being brought up to the roots by capillary action. The ground was also full of plant food. These beets, therefore, had the very best possible conditions and they improved their opportunities. The rows were 18 inches apart, and the beets thinned to 9 inches apart in the row. The stand was perfect and the growth enormous. Toward the latter part of the season the tops crowded so that the patch seemed one large beet. It was impossible to see any ground or to distinguish one beet from another. The beets averaged five pounds each and almost touched each other, making practically a solid row of beets.

As would be expected under these conditions, they never ripened and their quality is low. The figures of the crop are as follows:



| Variety.                        | Crop per<br>acre<br>Tons. | Sugar in<br>beet. | Purity. |
|---------------------------------|---------------------------|-------------------|---------|
| Utah Kleinwanzlebener.....      | 105.5                     | 8.88              | 64.6    |
| Original Kleinwanzlebener ..... | 123.4                     | 8.93              | 66.3    |
| Vilmorin.....                   | 90.2                      | 9.65              | 67.9    |
| Mangold .....                   | 81.1                      | 9.11              | 65.5    |
| Eddy Kleinwanzlebener.....      | 98.5                      | 10.36             | 69.5    |
| Elite Kleinwanzlebener .....    | 102.2                     | 10.45             | 70.6    |
| Average . .....                 | 100.1                     | 9.56              | 67.4    |

This is over 19,000 pounds of sugar per acre.

## A SHIPMENT OF SUGAR BEETS TO GRAND ISLAND, NEBRASKA.

As will be given more in detail later, the Business Men's Association, of Loveland, Colorado, in connection with the Denver Chamber of Commerce, offered prizes for the best crops of sugar beets raised in the vicinity of Loveland. The officials of the Union Pacific, Denver and Gulf Railroad considered that this would be a good opportunity to test the beets of northern Colorado on a commercial scale. They obtained several hundred pounds of beet seed from the Oxnard Sugar Company, of Grand Island, Nebraska, and distributed this to the farmers of Loveland and vicinity, free of charge, on condition that the growers ship their beets to Grand Island. Instructions in regard to the methods of growing beets were sent to each one, by the College; the present writer visited a good many of the farms during the growing season and took notes on the crop and the care it had received, and as the season advanced he took samples for analysis at various times until it was evident that the crops were ripe enough to ship.

The changes of the crop in the process of ripening and the date when the crop was ready for harvesting, can be gathered from the following samples that were among those taken at Loveland:

| Name.                | Dated when sample was taken. | Sugar in beet. | Purity. |
|----------------------|------------------------------|----------------|---------|
| R. S. Cox .....      | Sept. 22                     | 12.45          | 73.4    |
| " " " .....          | Oct. 4                       | 12.73          | 78.5    |
| " " " .....          | " 20                         | 13.40          | 75.7    |
| John Hahn .....      | Sept. 22                     | 14.21          | 76.6    |
| " " .....            | Oct. 4                       | 14.54          | 83.7    |
| " " .....            | " 20                         | 17.39          | 83.7    |
| C. C. Smith.....     | " 4                          | 13.87          | 79.4    |
| " " " .....          | " 27                         | 14.73          | 79.0    |
| N. R. Faulkner ..... | " 4                          | 10.93          | 72.1    |
| " " " .....          | " 22                         | 12.07          | 74.0    |
| Alvin Shields.....   | " 3                          | 13.30          | 81.2    |
| " " .....            | " 29                         | 15.96          | 86.8    |
| J. S. Steele.....    | " 4                          | 13.06          | 76.6    |
| " " " .....          | " 29                         | 15.68          | 82.9    |
| Harvey Skinner ..... | " 3                          | 16.53          | 84.5    |
| " " .....            | " 27                         | 17.38          | 85.3    |
| I. W. Clapper .....  | " 4                          | 16.15          | 83.9    |
| " " " .....          | Nov. 1                       | 18.53          | 80.4    |
| D. Hershman .....    | Oct. 18                      | 12.11          | 77.5    |
| " " .....            | " 31                         | 14.06          | 74.9    |
| P. C. Benson .....   | " 3                          | 17.96          | 83.6    |
| " " " .....          | " 20                         | 17.77          | 84.0    |
| " " " .....          | " 31                         | 19.05          | 86.0    |

According to these figures, a factory could have found beets in proper condition for working the last week in September, and ten days later nearly half the crops were of excellent quality. All of the fields improved in quality during October, and some of the more backward were hardly ripe before the end of the month.

Harvesting for shipment to Grand Island began on October 28 and was completed November 2. Six carloads were shipped from Loveland, two from Fort Collins and one from Greeley. Each wagonload of beets was weighed when brought to the cars and samples of the beets taken for analysis. When the cars reached Grand Island they were weighed, the beets again analyzed, and also a sample was cleaned to ascertain how much dirt was attached to the beets.



| Name.                       | Date of<br>harvesting. | Sugar in beet. | Purity. |
|-----------------------------|------------------------|----------------|---------|
| E. E. Bassett, No. 1.....   | Oct. 28                | 17.48          | 85.3    |
| Harvey Skinner, No. 1.....  | " 28                   | 15.06          | 79.4    |
| " " No. 2.....              | " 28                   | 17.32          | 83.1    |
| " " No. 3.....              | " 28                   | 18.15          | 87.4    |
| H. L. Boyd, No. 1.....      | " 28                   | 17.10          | 85.0    |
| John Hokanson.....          | " 28                   | 17.39          | 84.2    |
| J. M. Naylor.....           | " 28                   | 16.15          | 84.7    |
| G. O. Wheelchel, No. 1..... | " 28                   | 15.63          | 86.8    |
| John Derby.....             | " 28                   | 18.77          | 84.5    |
| Pugh and Merry, No. 1.....  | " 29                   | 13.73          | 75.4    |
| " " " No. 2.....            | " 29                   | 14.73          | 81.8    |
| R. S. Cox, No. 1.....       | " 29                   | 13.82          | 78.2    |
| " " No. 2.....              | " 29                   | 12.83          | 75.4    |
| J. S. Steele.....           | " 29                   | 15.68          | 82.9    |
| E. E. Bassett, No. 2.....   | " 29                   | 17.77          | 84.8    |
| J. W. Flinn.....            | " 29                   | 16.63          | 83.4    |
| H. L. Boyd, No. 2.....      | " 29                   | 16.91          | 84.5    |
| J. R. Samuels.....          | " 29                   | 14.96          | 83.0    |
| I. O. Hollowell, No. 1..... | " 29                   | 16.58          | 78.1    |
| " " No. 2.....              | " 29                   | 16.63          | 82.6    |
| P. C. Benson, No. 1.....    | " 29                   | 19.33          | 87.9    |
| " " No. 2.....              | " 29                   | 19.14          | 87.5    |
| C. H. Brown.....            | " 29                   | 16.34          | 84.7    |
| H. C. Caldwell, No. 1.....  | " 29                   | 12.97          | 73.7    |
| W. H. Fairbrother.....      | " 29                   | 15.87          | 80.9    |
| W. M. Pugh.....             | " 29                   | 14.20          | 78.1    |
| J. J. Youtsey.....          | " 29                   | 18.00          | 87.2    |
| G. O. Wheelchel, No. 2..... | " 29                   | 18.53          | 86.6    |
| W. S. Warner, No. 1.....    | " 29                   | 17.53          | 80.1    |
| Alfred Wild.....            | " 31                   | 15.25          | 80.7    |
| F. G. Bartholf, No. 1.....  | " 31                   | 13.83          | 78.0    |
| D. Hershman.....            | " 31                   | 14.06          | 74.9    |
| E. F. Abernathy.....        | " 31                   | 15.34          | 78.2    |
| W. S. Warner, No. 2.....    | " 31                   | 18.24          | 84.0    |
| Alvin Shields, No. 1.....   | " 31                   | 14.39          | 77.8    |
| " " No. 2.....              | " 31                   | 15.96          | 86.8    |
| H. C. Caldwell, No. 2.....  | " 31                   | 16.15          | 82.0    |
| John Hahn.....              | " 31                   | 15.01          | 75.5    |
| P. C. Benson, No. 3.....    | Nov. 2                 | 19.05          | 86.0    |
| F. G. Bartholf, No. 2.....  | " 2                    | 15.68          | 85.3    |
| C. A. Anderson, No. 1.....  | " 2                    | 15.96          | 86.0    |
| " " No. 2.....              | " 2                    | 15.44          | 87.7    |

The six cars of beets from Loveland were several days on the road, and of course dried out considerably. This would tend to lower the weight and raise the analysis, as is seen in the table below

| Car.                   | Loveland weight. | Grand Island weight. | LOVELAND ANALYSIS. |         | GRAND ISLAND ANALYSIS. |         |
|------------------------|------------------|----------------------|--------------------|---------|------------------------|---------|
|                        |                  |                      | Sugar in beet.     | Purity. | Sugar in beet.         | Purity. |
| U. P. 27599.....       | 31070            | 29600                | 16.00              | 84.8    | 17.1                   | 84.8    |
| O. R. & N. 6147.....   | 30850            | 30000                | 15.24              | 81.5    | 16.8                   | 83.7    |
| U. P. 40847.....       | 31870            | 30800                | 15.60              | 82.3    | 16.9                   | 80.8    |
| U. P. D. & G. 26964... | 19000            | 17700                | 14.50              | 80.7    | 16.0                   | 82.8    |
| U. P. 66800.....       | 29460            | 25800                | 15.19              | 81.0    | 15.8                   | 80.2    |
| U. P. 41001.....       | 17590            | 16700                | 15.62              | 85.7    | 15.8                   | 79.8    |
| Average.....           | 26640            | 25100                | 15.36              | 82.7    | 16.4                   | 82.0    |

The above shows a shrinkage, during the time of shipping, of 1,540 pounds per carload, or 6 per cent. In addition to this shrinkage, there was a still further deduction made for the "tare," or the dirt on the beets, and improper trimming. After making both these allowances, the record stands as follows :

| Car.                     | Grand Island weight. | Per cent of tare. | Net weight. | Sugar in beet. | Purity. | Price for beets per ton. | Pure sugar per car. |
|--------------------------|----------------------|-------------------|-------------|----------------|---------|--------------------------|---------------------|
| U. P. 27599.....         | 29600                | 11.0              | 26344       | 17.1           | 84.8    | \$4.75                   | 4505                |
| O. R. & N. 6147.....     | 30000                | 7.0               | 27900       | 16.8           | 83.7    | 4.75                     | 4687                |
| U. P. 40847.....         | 30800                | 9.0               | 28028       | 16.9           | 80.8    | 4.75                     | 4737                |
| U. P. D. & G. 26964..... | 17700                | 5.0               | 15930       | 16.0           | 82.8    | 4.50                     | 2549                |
| U. P. 66800.....         | 25800                | 13.0              | 22446       | 15.8           | 80.2    | 4.50                     | 3547                |
| U. P. 41001.....         | 16700                | 10.0              | 15030       | 15.8           | 79.8    | 4.50                     | 2375                |
| Average.....             | .....                | 10.0              | .....       | 16.4           | 82.0    | \$4.62                   | .....               |
| Total.....               | 150600               | .....             | 135678      | .....          | .....   | .....                    | 22400               |

No complete records were kept of yield per acre. There was some trouble about getting the cars for shipment, and owing to a shortage of cars there were so many beets that had been raised that were not shipped that it was impossible in several cases to tell the amount of land on which the part of the crop grew that was shipped. We have the records of about three-fourths of the beets, and the average of these is a trifle less than nineteen tons to the acre, gross weight, or, after taking out the tare, a little over seventeen tons net per acre. This gives about 5,300 pounds of pure sugar per acre, or about 300 pounds more sugar per acre for these



crops at Loveland raised under field conditions, than is found as the average of the whole state for the crops grown in competition for the sugar beet prizes.

This shipment of beets is one of the best ever made where the crop came from so many different farms, and shows conclusively that Colorado soil and climate are wonderfully adapted to the sugar beet.

In this connection, it seems proper to add the records of some shipments of sugar beets made in 1893 and 1894 from Grand Junction and vicinity to the sugar factory at Lehi, Utah :

| <i>Date of shipment.</i>   | <i>No. of cars.</i> | <i>Sugar in beet.</i> | <i>Purity.</i> |
|----------------------------|---------------------|-----------------------|----------------|
| Nov. 15, 1893 .....        | 1                   | 15.7                  | 84.0           |
| “ 20, “ .....              | 1                   | 16.2                  | 84.0           |
| “ 20, “ .....              | 1                   | 15.0                  | 84.0           |
| 1894.....                  | 1                   | 14.7                  | 88.4           |
| “ .....                    | 2                   | 14.2                  | 84.2           |
| “ .....                    | 1                   | 12.6                  | 78.5           |
| Average of seven cars..... |                     | 14.7                  | 83.7           |

## SUGAR BEETS AT GRAND JUNCTION.

The bulletins of the Agricultural College contain nearly all of the analyses that have ever been made of Colorado sugar beets. In order to make the record complete, it is deemed best to insert here two sets of analyses made in the years 1893 and 1894 of beets raised in the valleys of the Grand and the Gunnison.

The seed was furnished by the Utah Sugar company of Lehi, Utah, the samples of the beets were taken with the greatest care by men sent out for that special purpose, and the analyses were all made at the sugar factory at Lehi. The first table gives the results of the season of 1893:

| Name.                | Date<br>planted. | FIRST SAMPLING. |                      |         | SECOND SAMPLING. |                      |         |
|----------------------|------------------|-----------------|----------------------|---------|------------------|----------------------|---------|
|                      |                  | Date.           | Sugar<br>in<br>beet. | Purity. | Date.            | Sugar<br>in<br>beet. | Purity. |
| P. A. Rice.....      | Apr. 20          | Sept. 27        | 13.0                 | 73.5    | Oct. 25          | 13.6                 | 73.6    |
| Mr. Currie.....      | " 20             | " 27            | 12.2                 | 73.5    | " 25             | 12.7                 | 76.1    |
| A. A. Miller.....    | " 20             | " 19            | 10.2                 | 72.3    | " 25             | 14.1                 | 81.3    |
| Indian School.....   | " 26             | .....           | .....                | .....   | " 19             | 16.0                 | 84.0    |
| A. J. McCune.....    | " 22             | " 27            | 10.0                 | 67.1    | " 25             | 11.7                 | 70.9    |
| Ed. Bravier.....     | " 22             | " 27            | 13.4                 | 76.1    | " 19             | 15.7                 | 85.0    |
| Eugene Allison.....  | " 28             | .....           | .....                | .....   | " 25             | 16.5                 | 81.3    |
| Ovid Turnill.....    | " 29             | .....           | .....                | .....   | " 25             | 13.3                 | 78.2    |
| W. H. Benkitt.....   | May 3            | " 27            | 12.0                 | 74.1    | Nov. 4           | 14.0                 | 78.3    |
| W. D. Spencer.....   | " 4              | " 27            | 11.5                 | 71.4    | Oct. 31          | 13.8                 | 78.5    |
| N. Poffenberger..... | " 8              | " 19            | 11.6                 | 73.5    | " 16             | 14.7                 | 81.0    |
| L. Johnson.....      | " 8              | " 19            | 9.5                  | 67.5    | " 25             | 12.6                 | 84.0    |
| W. F. Shewel.....    | " 9              | " 27            | 9.0                  | 67.7    | " 25             | 10.4                 | 76.5    |
| Joseph Smith.....    | " 9              | .....           | .....                | .....   | " 25             | 14.8                 | 83.9    |
| John Vaughn.....     | " 10             | " 27            | 12.4                 | 72.1    | .....            | .....                | .....   |
| M. S. Hildreth.....  | " 11             | .....           | .....                | .....   | " 31             | 12.8                 | 77.2    |
| J. C. Sullivan.....  | " 12             | .....           | .....                | .....   | " 31             | 12.3                 | 72.2    |
| Frank Leach.....     | " 15             | " 19            | 12.7                 | 76.4    | " 25             | 15.0                 | 82.0    |
| Geo. Davis.....      | " 17             | .....           | .....                | .....   | " 31             | 17.2                 | 76.3    |
| C. N. Cox .....      | " 23             | " 27            | 10.4                 | 68.3    | " 25             | 15.1                 | 81.5    |
| Smith Bros.....      | " 15             | .....           | .....                | .....   | " 25             | 16.1                 | 83.7    |
| Mr. Almes.....       | " 15             | .....           | .....                | .....   | " 31             | 12.5                 | 78.8    |
| Frank Rich.....      | " 23             | " 27            | 11.6                 | 70.0    | " 25             | 17.0                 | 84.5    |
| W. E. Renick.....    | " 25             | " 19            | 12.3                 | 77.7    | " 16             | 11.6                 | 68.9    |
| John Peugh.....      | " 26             | " 19            | 11.0                 | 75.3    | .....            | .....                | .....   |
| J. O'Keefe.....      | " 30             | " 27            | 11.0                 | 78.8    | .....            | .....                | .....   |
| J. A. Lawton.....    | " 30             | " 27            | 10.9                 | 69.4    | .....            | .....                | .....   |

During the month from the latter part of September to the last of October the beets improved about two per cent in sugar and nearly ten per cent in purity. The shipments of carload lots were not made until late in November, and the beets of those that shipped had made by that time a still farther gain of one per cent in sugar.

The above crops represent all kinds of soil from one end of Grand valley to the other.

This was the first season that these farmers had raised sugar beets, and the general tendency was to give too much water and too little cultivation. Some of the fields had one cultivation, a smaller number were cultivated twice, and most of them had no cultivation



at all. In only a few cases was the thinning done with any degree of care.

In every case where the last analysis has shown a purity less than 80, the crop was irrigated from two to four times.

The work was repeated in 1894, and as many of the growers had had the benefit of the previous year's experience, the tests as a whole show an improvement. Only one set of samples was taken, and the results show that several of these were taken before the beets were ripe.

| Sample Number. | Num-ber of beets in sample. | Sugar in beet. | Purity. | Sample Number. | Num-ber of beets in sample. | Sugar in beet. | Purity. |
|----------------|-----------------------------|----------------|---------|----------------|-----------------------------|----------------|---------|
| 1.....         | 6                           | 16.0           | 84.4    | 21.....        | 6                           | 16.1           | 85.0    |
| 2.....         | 9                           | 13.0           | 78.2    | 22.....        | 6                           | 12.8           | 79.4    |
| 3.....         | 9                           | 15.8           | 78.0    | 23.....        | 4                           | 12.2           | 73.1    |
| 4.....         | 6                           | 12.5           | 72.0    | 24.....        | 9                           | 14.4           | 81.3    |
| 5.....         | 5                           | 16.8           | 86.2    | 25.....        | 4                           | 11.9           | 75.3    |
| 6.....         | 4                           | 15.0           | 74.5    | 26... ..       | 4                           | 12.8           | 76.7    |
| 7.....         | 4                           | 14.2           | 78.8    | 27.....        | 7                           | 12.5           | 69.6    |
| 8.....         | 6                           | 15.8           | 86.3    | 28.....        | 9                           | 15.1           | 84.6    |
| 9.....         | 7                           | 12.0           | 78.8    | 29.....        | 4                           | 13.3           | 81.4    |
| 10.....        | 4                           | 17.5           | 87.4    | 30.....        | 18                          | 17.6           | 85.6    |
| 11.....        | 3                           | 16.0           | 83.3    | 31.....        | 7                           | 13.9           | 81.6    |
| 12.....        | 4                           | 18.0           | 87.0    | 32.....        | 8                           | 15.0           | 84.0    |
| 13.....        | 4                           | 17.5           | 86.1    | 33.....        | 5                           | 14.3           | 77.3    |
| 14.....        | 8                           | 17.0           | 86.2    | 34.....        | 2                           | 12.8           | 79.0    |
| 15 .....       | 4                           | 14.7           | 82.9    | 35.....        | 9                           | 15.2           | 82.0    |
| 16.....        | 5                           | 12.1           | 74.2    | 36.....        | 4                           | 12.6           | 74.3    |
| 17.....        | 5                           | 16.9           | 85.6    | 37.....        | 8                           | 15.0           | 83.7    |
| 18.....        | 6                           | 13.5           | 79.3    | 38.....        | 1                           | 15.7           | 84.6    |
| 19 .....       | 5                           | 14.6           | 81.5    | 39.....        | 11                          | 14.5           | 83.1    |
| 20.....        | 7                           | 15.0           | 82.9    |                |                             |                |         |

Several of these samples deserve special attention. Numbers 2, 18 and 34 grew very large beets, from four to six pounds weight each, and had an enormous weight per acre, and yet, although these beets are not so rich as some of the others they are above the stand-ard required by factories and would have brought a large return per acre. Numbers 27 and 28 came from the same field, the first from sandy soil and the other from heavy adobe soil. Number 39 is also from sandy soil, while number 30 is from new land and heavy adobe. In both cases the sandy soil gives poorer beets than

the heavy soil. The same has been noted in northeastern Colorado, where the heavy soil, though harder to work, gives a better quality of beet.

Numbers 1, 5, 10, and 17 had had previous experience in raising beets, and their crops averaged 16.8 sugar and 85.9 purity, showing that care and experience are all that are needed to raise the best of beets in the valley of the Grand.

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## SUGAR BEET PRIZES.

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It was recognized in the spring of 1898, that the time had come when there should be a well organized effort to get the most exact information possible on the adaptation of the sugar beet to Colorado soil and climate. Nearly all the estimates of previous beet crops in Colorado have been based on the yield from a hundred square feet of ground. It was recognized by all that this was too small a plot for commercial estimates. It had been adopted because the beet growers disliked to spend the large amount of time and trouble necessary to make exact experiments on a large scale. It was seen that some substantial inducement must be offered before it could be expected that better results could be obtained than those of former years.

Acting on this idea, the Denver Chamber of Commerce offered \$1,000 in cash prizes to those who grew the best crops of beets, these to be grown on a commercial scale, and each to cover 2,700 square feet of ground. The offer was conditioned on the appropriation of certain sums for the same purpose by the County Commissioners of each county. This was done by the County Commissioners of the following counties: Conejos, Costilla, Delta, Logan, Mesa, Otero and Weld. In Larimer county the money was subscribed by the business men of Loveland; in Fremont county by the Canon City Chamber of Commerce; while in Garfield county prizes were offered by the Denver and Rio Grande and by the Colorado Midland railroads.

The following instructions were sent to those who desired to compete for these prizes:



## COLORADO AGRICULTURAL COLLEGE.

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### DIRECTIONS FOR HARVESTING THE CROP.

The plot of beets selected to compete for the prizes must contain, as nearly as possible, one-sixteenth of an acre, and must be all in one continuous piece. Call in a neighbor to witness harvesting and certify to the weights and measures.

Begin on one side and harvest every other row, *but no row harvested should be an outside row, i. e.*, if the plot selected is on the outside of the field, begin with the second row and harvest every other row.

Cut off the tops of the beets just at the base of the leaves, Shake the beets free from any loose dirt, and weigh the crop in this condition. This is the one referred to later as the "gross weight."

Throw the beets into a pile and roughly divide the pile in the middle, and again divide one of the halves in the middle, giving one-fourth of the original crop. Throw this fourth into a pile and treat it the same way, so that you have a fourth of a fourth, or about one-sixteenth of the crop. Weigh this lot and record it as the "gross weight of one-sixteenth of crop." Scrape these beets with a dull knife until they are free from dirt, fibrous roots and any stubs of leaves that may have been left on the crown. Weigh again and call this the "net weight of one-sixteenth of crop."

Count the number of beets in this last lot, and then select from it four to eight beets that together will weigh about eight pounds, and will be representative of the crop, *i. e.*, select big, medium and little, good shaped and bad, so as to get a fair sample of the lot. Weigh these beets together *very carefully*, and record this as "weight of sample for analysis."

Wrap each of the beets separately in paper and then do them up in two packages, not to exceed four pounds in each package, sew each package up securely in cloth and attach the mailing tag, which will enable the package to be sent postage free.

The harvesting, weighing and preparing the sample for analysis should all be done on the same day, and as quickly as possible to prevent drying out.

Three blanks are sent you; one to be filled out and enclosed in each package, and the other to be kept by you for your own information.

Mail the sample for analysis as soon as possible after it is ready. The receipt of the sample for analysis will be acknowledged by return mail.

*Do not harvest the rest of the plot until you receive word that your sample and records are satisfactory.* By this means it may be possible to correct mistakes, if any have accidentally been made.

It will be seen from the instructions, that it was desired that the crops be harvested and sampled between October 15 and November 1. In the case of Logan county, the crops were harvested the last week in September, so that they could be exhibited at the county fair. The crops were not then ripe and the results are much poorer, both in quantity and quality, than would have been obtained had the beets remained in the ground a month longer. At the request of the present writer, two of these fields were but partly harvested, and the rest of the beets were pulled the latter part of October, when the beets in the other counties were being harvested. In each case the beets tested in sugar more than three per cent higher than during September.

It was desired that the contest be put as nearly as possible on a commercial basis, *i. e.*, the prizes be awarded to the crops in the order of their real value for sugar making purposes. It was necessary then, to take into account three things: The weight of the

crop, the amount of sugar in the crop, and the amount of sugar that could be gotten out in the factory. These items are given in the accompanying tables. The column headed "Gross weight of trimmed beets per acre," gives the weight of the beets in the same condition as they would ordinarily be brought to a factory, *i. e.*, with the tops cut off, but no attempt made to remove the dirt that naturally sticks to the beet. At a factory, a sample of the beets, usually about half a bushel, is taken and cleaned and the calculation made as to how much dirt there is in the whole load.

The column headed "Sugar in the beet," represents the character of the beet at the time it was analyzed. On the average, this was about three days after harvesting. During this time, of course, the beets had been drying out, which would tend to raise the per cent of sugar in the sample. The first two columns, therefore, represent the gross weight of beets and dirt together and the analysis of a partly dried sample, in both cases making the crops apparently better than they were. To offset this, the column headed, "Pure sugar per acre," is obtained by multiplying the other two together and deducting one-fifth for tare and drying out. It is probable that this is a larger shrinkage than would have been made had these crops been sent to a sugar factory, but it is deemed best to make sufficient reduction so there could be no possible appearance of an attempt to exaggerate Colorado's sugar beet crops. The figures, even after the 20 per cent reduction, show magnificent crops, and still more so that we can look at them as a slight underestimate.

The column headed "Purity," is the measure of the factory value of the sugar that is in the beet. If a lot of beets test 80 purity, it means that for every 80 pounds of pure sugar they contain, they also have 20 pounds of impurities that are not sugar. These impurities prevent the factory from saving all the pure sugar, and the greater the amount of impurity the greater the amount of pure sugar that will be lost in the process of manufacture. The "pure sugar per acre," multiplied by the "purity" will give the "available sugar per acre," or the approximate amount of sugar that would have been produced from the crops in an ordinary factory. It is considered that this measures the true sugar value of the crop, and it is on the figures of this column that the order of excellence of the various crops is based.

In the table of averages by counties, another column is introduced headed "Factory value per acre." It is obtained by deducting ten per cent tare from the gross weight of the crop and multiplying the remainder by the price paid during 1898 by factories where the price is varied according to the quality of the beets. The prices used are :

\$3.75 per ton for beets testing less than 14.4 sugar and less than 78 purity.



\$4.00 per ton for the same sugar and more than 78 purity.  
 \$4.25 per ton for tests from 14.5 to 15.4 sugar.  
 \$4.50 " " " " " 15.5 to 16.4 "  
 \$4.75 " " " " of 16.5 sugar or higher.

CONEJOS COUNTY.

| Name and Place.                   | Date of<br>harvest-<br>ing the<br>crop. | Gross<br>weight<br>of<br>trim'ed<br>beets<br>per<br>acre.<br>Tons. | Sugar<br>in<br>beet. | Purity. | Pure<br>sugar<br>per<br>acre.<br>Lbs. | Avail-<br>able<br>sugar<br>per<br>acre.<br>Lbs. |
|-----------------------------------|-----------------------------------------|--------------------------------------------------------------------|----------------------|---------|---------------------------------------|-------------------------------------------------|
| Chas. Milne, La Jara.....         | Nov. 7                                  | 28.16                                                              | 17.65                | 79.8    | 7952                                  | 6436                                            |
| W. M. Martin, Alamosa.....        | Oct. 29                                 | 24.57                                                              | 16.96                | 86.8    | 6684                                  | 5802                                            |
| W. A. Braiden, La Jara.....       | " 10                                    | 20.05                                                              | 11.45                | 72.2    | 3673                                  | 2803                                            |
| D. E. Newcomb, La Jara.....       | " 12                                    | 12.80                                                              | 15.65                | 80.1    | 3205                                  | 2563                                            |
| S. J. Parish, Alamosa.....        | " 16                                    | 12.06                                                              | 16.64                | 80.5    | 3174                                  | 2554                                            |
| J. L. Rutledge, La Jara .....     | " 15                                    | .....                                                              | 18.91                | 84.4    | .....                                 | .....                                           |
| J. W. Dove, Alamosa.....          | .....                                   | .....                                                              | 13.19                | 78.0    | .....                                 | .....                                           |
| Mrs. N. A. Broyles, Antonito..... | " 15                                    | .....                                                              | 11.97                | 70.9    | .....                                 | .....                                           |
| Average .....                     | Oct. 21                                 | 19.53                                                              | 15.67                | 80.0    | 4689                                  | 3741                                            |

COSTILLA COUNTY.

|                            |         |       |       |       |       |       |
|----------------------------|---------|-------|-------|-------|-------|-------|
| G. W. Shaw, Alamosa.....   | Oct. 22 | 12.29 | 15.30 | 86.6  | 3008  | 2605  |
| A. McKinnon, Alamosa ..... | " 18    | 7.26  | 12.54 | 83.8  | 1457  | 1213  |
| Peter Legard, Alamosa..... | " 20    | ..... | 15.58 | ..... | ..... | ..... |
| N. E. Morgan, Hooper ..... | Nov. 7  | ..... | 20.43 | 83.2  | ..... | ..... |
| R. W. Maddux, Mosca.....   | Oct. 15 | ..... | 12.40 | 83.8  | ..... | ..... |
| Wm. Douglas, Mosca.....    | " 18    | 22.60 | ..... | ..... | ..... | ..... |
| Average.....               | Oct. 22 | 14.05 | 15.42 | 84.3  | 3093  | 2607  |

DELTA COUNTY.

|                                |         |       |       |      |       |       |
|--------------------------------|---------|-------|-------|------|-------|-------|
| G. H. Hammond, Hotchkiss ..... | Oct. 22 | 38.51 | 17.34 | 77.4 | 10962 | 8485  |
| Martin Cade, Delta.....        | " 17    | 20.57 | 15.91 | 89.5 | 5236  | 4686  |
| G. W. Umbrell, Delta .....     | " 31    | 21.78 | 14.68 | 80.9 | 5116  | 4139  |
| I. S. Hewitt, Delta.....       | " 19    | 19.96 | 12.87 | 71.0 | 4118  | 2924  |
| J. M. Trew, Delta.....         | " 19    | 10.87 | 13.40 | 76.5 | 2331  | 1783  |
| Charles A. Barnes, Delta ..... | " 28    | ..... | 15.44 | 83.9 | ..... | ..... |
| Average .....                  | Oct. 23 | 22.54 | 14.74 | 80.0 | 5301  | 4241  |

**FREMONT COUNTY.**

| Name and Place.                     | Date of<br>harvest-<br>ing the<br>crop. | Gross<br>weight<br>of<br>trim'ed<br>beets<br>per<br>acre.<br>Tons. | Sugar<br>in<br>beet. | Purity. | Pure<br>Sugar<br>per<br>acre.<br>Lbs. | Avail-<br>able<br>sugar<br>per<br>acre.<br>Lbs. |
|-------------------------------------|-----------------------------------------|--------------------------------------------------------------------|----------------------|---------|---------------------------------------|-------------------------------------------------|
| B. F. Rockafellow, Canon City ..... | Oct. 21                                 | 30.05                                                              | 18.05                | 86.8    | 8678                                  | 7533                                            |
| William Curtis, Canon City.....     | " 29                                    | 29.18                                                              | 16.63                | 86.9    | 7766                                  | 6748                                            |
| L. K. Mortimer, Canon City.....     | Nov. 2                                  | 26.35                                                              | 17.96                | 83.5    | 7589                                  | 6337                                            |
| Charles Kaess, Cotopaxi.....        | Oct. 24                                 | 29.40                                                              | 16.63                | 79.6    | 7822                                  | 6226                                            |
| G. E. Murray, Howard .....          | " 15                                    | 29.80                                                              | 15.33                | 84.3    | 7310                                  | 6162                                            |
| W. A. Dumm, Canon City.....         | " 28                                    | 21.33                                                              | 18.05                | 82.0    | 6160                                  | 5051                                            |
| J. M. Murray, Howard.....           | " 15                                    | 29.52                                                              | 13.63                | 79.4    | 6444                                  | 5117                                            |
| John Ripley, Canon City.....        | " 27                                    | 21.90                                                              | 16.96                | 80.3    | 5942                                  | 4772                                            |
| H. T. Gravestock, Canon City.....   | " 20                                    | 14.50                                                              | 16.48                | 90.7    | 3831                                  | 3475                                            |
| E. S. Armstrong, Hillside .....     | " 12                                    | 16.13                                                              | 15.68                | 77.7    | 4046                                  | 3116                                            |
| C. H. Gravestock, Canon City.....   | " 28                                    | 8.45                                                               | 19.00                | 84.8    | 2569                                  | 2178                                            |
| E. V. Kimmel, Canon City.....       | " 20                                    | .....                                                              | 18.05                | 93.5    | .....                                 | .....                                           |
| Phil Sheriden, Canon City .....     | " 18                                    | .....                                                              | 19.10                | 81.3    | .....                                 | .....                                           |
| B. F. Rockafellow, Canon City ..... | " 29                                    | .....                                                              | 18.24                | 81.8    | .....                                 | .....                                           |
| J. E. Brown, Canon City.....        | .....                                   | .....                                                              | 14.42                | 81.3    | .....                                 | .....                                           |
| A. C. Haggart, Canon City.....      | " 20                                    | .....                                                              | 12.06                | 67.7    | .....                                 | .....                                           |
| Average .....                       | Oct. 23                                 | 23.36                                                              | 16.87                | 84.1    | 6226                                  | 5236                                            |

**GARFIELD COUNTY.**

|                                 |         |       |       |      |       |       |
|---------------------------------|---------|-------|-------|------|-------|-------|
| C. H. Harris, Catherin .....    | Oct. 29 | 37.98 | 17.20 | 80.1 | 10458 | 8397  |
| D. G. Edgerton, Carbondale..... | " 18    | 14.91 | 17.34 | 91.8 | 4113  | 3776  |
| Jesse Kerlee, Parachute .....   | " 19    | 10.77 | 15.68 | 88.0 | 2702  | 2378  |
| Charles H. Miller, Antlers..... | " 17    | 12.17 | 14.25 | 79.4 | 2774  | 2203  |
| W. C. Parker, New Castle.....   | .....   | ..... | 17.39 | 82.9 | ..... | ..... |
| C. M. Rulison, Parachute.....   | .....   | ..... | 15.89 | 82.2 | ..... | ..... |
| Harry Brenton, Rifle.....       | .....   | ..... | 15.91 | 83.6 | ..... | ..... |
| F. W. Mallory, New Castle.....  | " 21    | ..... | 15.96 | 76.1 | ..... | ..... |
| E. E. Westhafer, Satank .....   | " 18    | ..... | 15.01 | 86.7 | ..... | ..... |
| F. M. Peebles, Satank .....     | .....   | ..... | 16.29 | 78.8 | ..... | ..... |
| Average .....                   | Oct. 21 | 18.96 | 16.12 | 84.8 | 4901  | 4153  |



LARIMER COUNTY.

| Name and Place.             | Date of<br>harvest-<br>ing the<br>crop. | Gross<br>weight<br>of<br>trim'd<br>beets<br>per<br>acre.<br>Tons. | Sugar<br>in<br>beet. | Purity. | Pure<br>sugar<br>per<br>acre.<br>Lbs. | Avail-<br>able<br>sugar<br>per<br>acre.<br>Lbs. |
|-----------------------------|-----------------------------------------|-------------------------------------------------------------------|----------------------|---------|---------------------------------------|-------------------------------------------------|
| J. M. Naylor, Loveland..... | Oct. 23                                 | 36.26                                                             | 16.53                | 79.3    | 9590                                  | 7589                                            |
| I. W. Clapper, " .....      | Nov. 1                                  | 31.60                                                             | 18.53                | 80.4    | 9369                                  | 7533                                            |
| C. C. Smith, " .....        | Oct. 27                                 | 33.01                                                             | 14.73                | 79.0    | 7781                                  | 6147                                            |
| F. G. Bartholf, " .....     | " 31                                    | 28.72                                                             | 15.68                | 85.3    | 7205                                  | 6142                                            |
| Alfred Wild, " .....        | " 27                                    | 31.50                                                             | 15.25                | 80.7    | 7606                                  | 6138                                            |
| Alvin Shields, " .....      | " 29                                    | 27.47                                                             | 17.43                | 79.7    | 7490                                  | 5970                                            |
| Harvey Skinner, " .....     | " 27                                    | 24.80                                                             | 17.38                | 85.3    | 6396                                  | 5882                                            |
| R. O. Joslyn, " .....       | " 27                                    | 14.10                                                             | 18.05                | 84.8    | 4072                                  | 3453                                            |
| R. S. Cox, " .....          | " 27                                    | 21.05                                                             | 13.40                | 75.7    | 4513                                  | 3416                                            |
| P. C. Benson, " .....       | " 31                                    | 10.72                                                             | 19.05                | 86.0    | 3267                                  | 2810                                            |
| N. R. Faulkner, " .....     | " 22                                    | 19.35                                                             | 12.07                | 74.0    | 3456                                  | 2765                                            |
| Average .....               | Oct. 28                                 | 25.32                                                             | 15.69                | 80.9    | 6356                                  | 5091                                            |

LOGAN COUNTY.

|                                 |          |       |       |      |       |       |
|---------------------------------|----------|-------|-------|------|-------|-------|
| Fred Bernhard, Sterling.....    | Sept. 26 | 34.15 | 13.40 | 72.7 | 7322  | 5323  |
| W. C. Propst, Merino.....       | " 25     | 24.50 | 14.72 | 76.2 | 5771  | 4397  |
| A. F. Krause, Sterling .....    | " 27     | 21.50 | 14.50 | 83.7 | 4988  | 4175  |
| J. H. King, Sterling .....      | " 27     | 18.10 | 13.30 | 79.1 | 3852  | 3047  |
| C. D. Brownell, Iliff.....      | " 26     | 14.60 | 14.72 | 80.0 | 3438  | 2750  |
| C. M. C. Woolman, Sterling..... | " 27     | 12.50 | 14.30 | 72.4 | 2860  | 2071  |
| C. E. Harter, " .....           | " 27     | 9.50  | 15.33 | 78.8 | 2331  | 1837  |
| T. A. Whiteley, " .....         | " 26     | 7.65  | 14.15 | 71.5 | 1730  | 1239  |
| James Weir, " .....             | " 26     | ..... | 14.49 | 78.2 | ..... | ..... |
| M. V. Propst, " .....           | " 26     | ..... | 14.25 | 78.8 | ..... | ..... |
| John Landrum, " .....           | Oct. 1   | ..... | 14.10 | 79.2 | ..... | ..... |
| R. C. Perkins, " .....          | Sept. 27 | ..... | 13.30 | 79.1 | ..... | ..... |
| H. C. Hatch, " .....            | " 26     | ..... | 12.63 | 73.3 | ..... | ..... |
| Average .....                   | Sept. 27 | 17.8  | 14.09 | 77.3 | 4013  | 3102  |

MESA COUNTY.

| Name and Place.                       | Date of<br>harvest-<br>ing the<br>crop. | Gross<br>weight<br>of<br>trim'ed<br>beets<br>per<br>acre.<br>Tons. | Sugar<br>in<br>beet. | Purity. | Pure<br>sugar<br>per<br>acre.<br>Lbs. | Avail-<br>able<br>sugar<br>per<br>acre.<br>Lbs. |
|---------------------------------------|-----------------------------------------|--------------------------------------------------------------------|----------------------|---------|---------------------------------------|-------------------------------------------------|
| Fred Burmeister, Grand Junction ..... | Oct. 1                                  | 36.0                                                               | 17.10                | 86.3    | 9850                                  | 8491                                            |
| J. D. Payne, Grand Jnnction .....     | Nov. 23                                 | 29.3                                                               | 16.57                | 76.0    | 7768                                  | 5904                                            |
| Adam May, Debeque .....               | " 14                                    | 22.0                                                               | 16.41                | 77.3    | 5776                                  | 4465                                            |
| W. K. Sterling, Collbran .....        | Oct. 26                                 | 21.0                                                               | 14.30                | 88.2    | 4805                                  | 4234                                            |
| Joseph Dietz, Fruita .....            | " 29                                    | 27.0                                                               | 13.54                | 71 6    | 5850                                  | 4183                                            |
| J. P. Veach, Fruita .....             | " 29                                    | 11.2                                                               | 19.81                | 85.4    | 3878                                  | 3313                                            |
| E. B. Bonnel, Grand Junction .....    | " 25                                    | 23.2                                                               | 11.40                | 68.2    | 4241                                  | 2932                                            |
| C. V. Wasson, Grand Junction .....    | Nov. 5                                  | 11.6                                                               | 16.15                | 75.8    | 3019                                  | 2289                                            |
| G. N. Patterick, Grand Junction ..... | " 2                                     | 16.5                                                               | 11.88                | 72.7    | 3142                                  | 2284                                            |
| S. M. Cox, Fruita .....               | Oct. 29                                 | .....                                                              | 15.16                | 77.0    | .....                                 | .....                                           |
| H. S. Groves, Fruita .....            | " 29                                    | .....                                                              | 14.16                | 78.4    | .....                                 | .....                                           |
| Lee D. Wilson, Grand Junction .....   | Nov. 21                                 | 11.7                                                               | .....                | .....   | .....                                 | .....                                           |
| Average .....                         | Nov. 2                                  | 20.9                                                               | 15.22                | 77.9    | 5114                                  | 3984                                            |

OTERO COUNTY.

|                                 |         |       |       |      |       |       |
|---------------------------------|---------|-------|-------|------|-------|-------|
| J. W. Ruble, Rocky Ford .....   | Oct. 25 | 31.40 | 18.19 | 86.2 | 9138  | 7877  |
| J. P. Pollock, La Junta .....   | Nov. 7  | 33.52 | 18.01 | 77.7 | 9652  | 7500  |
| B. F. Wyckoff, Rocky Ford ..... | Oct. 25 | 23.21 | 14.16 | 78.3 | 5259  | 4108  |
| Albert Conner, Rocky Ford ..... | " 27    | 27.70 | 10.83 | 72.8 | 4800  | 3494  |
| C. S. McKinley, Fowler .....    | " 20    | 13.27 | 16.06 | 84.7 | 3411  | 2889  |
| Fred Janrow, Fowler .....       | " 29    | 18.17 | 13.30 | 73.6 | 3906  | 2875  |
| Richard Mason, Higbee .....     | " 20    | 10.70 | 15.20 | 78.3 | 2603  | 2048  |
| C. S. Heath, La Junta .....     | " 26    | ..... | 15.39 | 76.8 | ..... | ..... |
| C. W. Ruckman, La Junta .....   | " 20    | ..... | 14.96 | 83.3 | ..... | ..... |
| M. A. Gordon, La Junta .....    | " 29    | ..... | 15.34 | 76.8 | ..... | ..... |
| Marten Sorensen, Fowler .....   | " 17    | ..... | 15.39 | 73.4 | ..... | ..... |
| Average .....                   | Oct. 26 | 22.59 | 15.14 | 79.8 | 5474  | 4379  |

WELD COUNTY.

|                                  |         |       |       |      |       |       |
|----------------------------------|---------|-------|-------|------|-------|-------|
| Leonard Burch, New Windsor ..... | Oct. 25 | 17.17 | 17.10 | 83.5 | 4699  | 3924  |
| Newton Clegg, Greeley .....      | " 25    | 12.20 | 16.25 | 78.1 | 3172  | 2477  |
| Martin Nelson, Greeley .....     | " 18    | 12.58 | 15.68 | 74 2 | 3154  | 2340  |
| Fritz Niemeyer, Evans .....      | " 26    | ..... | 14 54 | 82.4 | ..... | ..... |
| C. F. Mason, Greeley .....       | " 13    | ..... | 14.44 | 81.2 | ..... | ..... |
| Average .....                    | Oct. 23 | 13.98 | 15.89 | 79.8 | 3562  | 2850  |



AVERAGE RESULTS BY COUNTIES.

| County.        | Date of<br>harvest-<br>ing of<br>crop. | Gross<br>weight<br>of<br>trim'ed<br>beets<br>per<br>acre.<br>Tons. | Sugar<br>in<br>beet. | Purity. | Pure<br>sugar<br>per<br>acre.<br>Lbs. | Avail-<br>able<br>sugar<br>per<br>acre.<br>Lbs. | Fac-<br>tory<br>value<br>per<br>acre. |
|----------------|----------------------------------------|--------------------------------------------------------------------|----------------------|---------|---------------------------------------|-------------------------------------------------|---------------------------------------|
| Conejos .....  | Oct. 21                                | 19.53                                                              | 15.67                | 80.0    | 46.89                                 | 3741                                            | \$ 79.11                              |
| Costilla ..... | " 20                                   | 14.05                                                              | 15.42                | 84.3    | 30.93                                 | 2607                                            | 56.92                                 |
| Delta.....     | " 23                                   | 22.54                                                              | 14.74                | 80.0    | 53.01                                 | 4241                                            | 86.23                                 |
| Fremont .....  | " 23                                   | 23.36                                                              | 16.87                | 84.1    | 6226                                  | 5236                                            | 99.75                                 |
| Garfield ..... | " 21                                   | 18.96                                                              | 16.12                | 84.8    | 4901                                  | 4155                                            | 76.98                                 |
| Larimer.....   | " 28                                   | 25.32                                                              | 15.52                | 80.2    | 6278                                  | 5023                                            | 102.56                                |
| Logan.....     | Sept. 27                               | 17.80                                                              | 14.09                | 77.3    | 4013                                  | 3102                                            | 64.00                                 |
| Mesa.....      | Nov. 2                                 | 20.90                                                              | 15.22                | 77.9    | 5114                                  | 3984                                            | 79.90                                 |
| Otero .....    | Oct. 26                                | 22.59                                                              | 15.14                | 79.8    | 5474                                  | 4374                                            | 86.40                                 |
| Weld .....     | Oct. 23                                | 13.98                                                              | 15.89                | 79.8    | 3562                                  | 2850                                            | 56.70                                 |
| Average .....  | Oct. 22                                | 19.90                                                              | 15.47                | 80.8    | 4950                                  | 4000                                            | \$ 76.07                              |

In considering the foregoing tables, one is struck at once with the high average excellence of the sugar beets of Colorado, as regards both quantity and quality. In the districts of the United States, where beets are raised for factories, 12 per cent of sugar and 78 purity are considered standards, and one who has raised ten to thirteen tons of beets to the acre is thought to have done well. A fair estimate of the cost of raising sugar beets is \$30 per acre, while the above table gives \$76.07 as the average factory value for the whole state. The difference of \$46.07 profit per acre will compare well with any other kind of farming practiced in Colorado, not even excepting the famed cantaloupes of the Arkansas valley, the orchards of the western slope, or the lambs of the northern feeding districts.

In concluding this portion of the subject, it is fitting that grateful appreciation should be expressed of the aid that the Denver Chamber of Commerce has given in this work. The above tables present the largest amount of the most reliable reports that have ever been collected concerning Colorado sugar beets, and their collection was made possible, only through the generosity and public spirit shown in offering the sugar beet prizes.





AGRICULTURAL EXPERIMENT STATION

1907

1899

# THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 52.

I. Pasturing Sheep on Alfalfa.

II. Raising Early Lambs.

*Approved by the Station Council,*

*ALSTON ELLIS, President.*

FORT COLLINS, COLORADO.

APRIL, 1899.

Bulletins will be sent to all residents of Colorado, interested in any branch of Agriculture, free of charge. Non-residents, upon application, can secure copies not needed for distribution within the State. The editors of newspapers to whom the Station publications are sent are respectfully requested to make mention of the same in their columns. Address all communications to the

DIRECTOR OF THE EXPERIMENT STATION,

Fort Collins, Colorado.

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FORT COLLINS, COLORADO.

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## I. PASTURING SHEEP ON ALFALFA.

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BY W. W. COOKE.

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The high price of sheep and lambs during the years since 1896 has turned the attention of sheep feeders to the question of raising the lambs they feed, in place of depending on the ranges of the south and west. The summer feed for the sheep, where there is no range, is the most difficult problem attending the raising of sheep on the ranches. It has been generally recognized that if it was as safe to pasture sheep on alfalfa as it is to let horses run on the same feed, there would be but little difficulty in raising lambs on any of the farms of the irrigated districts of Colorado. Many have tried pasturing sheep and lambs on alfalfa, but so many sheep have been lost by bloat that most herders have dropped the practice and others have been deterred from attempting it.

The high price of sheep has again awakened interest in the subject and led to the following experiments and investigation:

In the early fall of 1897 we bought eleven ewes for the purpose of making a double test, *i. e.*, the raising of early lambs and the pasturing of these lambs and the ewes on alfalfa during the summer of 1898. The ewes were mixed Shropshire and Merino, weighing about ninety pounds apiece. They were old ewes that had still fairly good teeth, but were so old that it was expected that the 1898 lamb would be the last one raised. They reached the college farm October 29, 1897, and were bred as soon as possible to the fine registered Shropshire ram Bennett's Prince, No. 87674, that stands at the head of the college flock. The eleven ewes dropped eleven lambs, most of them within a week after March 4, 1898. Through the winter the ewes were fed alfalfa hay. They received a small amount of ensilage during part of the winter, but in figuring on the finan-

cial side of the transaction this has been counted at its equivalent feeding value in alfalfa. As soon as the lambs were dropped, some grain was added to the feed and both ewes and lambs were turned on to alfalfa April 20. At this time the young alfalfa was barely showing green and the feeding of alfalfa hay and grain was continued until the green alfalfa was about four inches high. At first they were given the run of a field containing about three-fourths of an acre of fairly good alfalfa and half an acre of poor alfalfa, which was considered equal to an acre of medium alfalfa. The season proved very dry and as the field could not be irrigated the alfalfa did not make enough growth to supply them all the food they needed. About the middle of June they were given access to a second field of two acres of alfalfa. Even with the aid of several pigs they could not keep up with both fields, and one cutting of the alfalfa was made for hay. It was estimated that the total green alfalfa eaten by the sheep and lambs was about equivalent to an acre and a half of good alfalfa that would cut from three to four tons of alfalfa hay to the acre during the whole season. The sheep were shut up at night in a small corral to keep them away from dogs and coyotes. During all the summer they were fed half a pound of bran per day per head, of both sheep and lambs. On June 12 one of the ewes died of bloat and on June 20 one of the lambs followed its example, leaving us ten ewes and ten lambs.

The ewes were sheared April 29, yielding 54 pounds of wool from the ten ewes, showing that they were rather light fleeced sheep.

The experiment closed September 6, at which time the ewes weighed an average of 103 pounds and the lambs an average of 94 pounds. We sold the ewes for \$3.50 per head. If we could have had the lambs in Chicago at that time they would have sold for \$6.00 per head, but we had too few to make a shipment and so they are counted at their value in the Colorado market, *i. e.*, \$4.00 per head. Thus the whole experiment was closed up in a few days over ten months.

#### SUMMARY.—Expenses.

|                                                                                  |         |
|----------------------------------------------------------------------------------|---------|
| To 11 ewes @ \$2.50 .....                                                        | \$27.50 |
| Service of ram .....                                                             | 2.50    |
| Alfalfa hay, 5 pounds per day per head<br>for 180 days, 5 tons @ \$4.00 per ton. | 20.00   |
| 1600 pounds of grain @ \$11.00 per ton...                                        | 8.80    |

---

Total expenses..... \$58.80



## Receipts.

|                                           |         |
|-------------------------------------------|---------|
| 54 pounds wool, less cost of shearing.... | \$ 7.00 |
| 10 ewes @ \$3.50.....                     | 35.00   |
| 10 lambs @ \$4.00.....                    | 40.00   |
|                                           | <hr/>   |
| Total receipts.....                       | \$82.00 |
|                                           | 58.80   |
|                                           | <hr/>   |
| Net return .....                          | \$23.20 |

The above amount, \$23.20, represents the return for the labor of caring for the sheep and for the acre and a half of alfalfa pasture. If the estimate is made that it costs thirty cents per head to look after sheep through the winter, which is a close approximation where many sheep are kept, there remain \$20.00 as the return for the alfalfa from one and a half acres of ground. This is more than four dollars a ton for alfalfa in the field, with the sheep doing all the haying, or more than five dollars a ton for the hay in the stack. These results also include the estimating the hay eaten during the winter at four dollars per ton.

It should be remembered that these are the financial results, notwithstanding a nine per cent. loss from bloat on both the ewes and the lambs. While it may be that less than nine per cent. loss cannot be safely estimated on the ewes, it is seldom that a lamb bloats on alfalfa pasture and it would be safe to expect no loss from this source.

It is a fair question whether we received an extra growth and corresponding return for the grain fed during the summer. This cannot be told, as we had no check lot not receiving grain. Other sheepmen in Colorado who pasture sheep on alfalfa are not in the habit of feeding grain after the alfalfa gets in good growth. But on the other hand they do not get so large a growth on their lambs as we did. The grain fed through the summer amounted to 700 pounds, or \$3.85 and it is probable, though not certain, that the lambs grew the 10 pounds each of live weight necessary to pay for the grain.

The only other person in the vicinity of Fort Collins who pastured sheep on alfalfa during the season of 1898 is C. W. Trimble. He pastured 40 ewes and 40 lambs on two acres of good alfalfa. They remained on the alfalfa day and night, rain and shine, all the season, except three times of four or five days each when the land was irrigated, then they were taken off and fed alfalfa hay. They had forty pounds of corn chop per day, *i. e.*, one pound a day for a ewe

and her lamb. None were lost by bloat of either ewes or lambs. After the third crop of alfalfa was cut the ewes and lambs were turned on the stubble to eat the fourth crop. The lambs were taken up in the latter part of September to feed for market. They weighed then about 65 pounds per head. The ewes remained in the fields until late. The same ewes are being kept for a repetition of the test in 1899.

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## PASTURING ALFALFA IN THE ARKANSAS VALLEY.

More attempts have been made in the Arkansas valley to pasture sheep on alfalfa than in any other part of Colorado. Some years when the feed on the range has been poor quite a large number of sheep have been pastured part of the season on alfalfa, but during the summer of 1898, the range grass was very abundant and nearly everybody turned the sheep and lambs on the range. The center of the sheep industry in the Arkansas valley is the counties of Otero, Bent and Prowers. Statements were obtained from those who had had the most experience in pasturing sheep on alfalfa and they are given herewith as showing what diverse results have been obtained and how various the opinions now held by those most familiar with the subject.

---

W. E. DOYLE, Pueblo.

We tried raising lambs on alfalfa pasture during the spring of 1898 and got along very well for the first two or three weeks while the pasture was short. But just as soon as the alfalfa got to growing faster than the sheep could eat it down close, they began to bloat, and before I gave it up I had lost about sixty head of fine Shropshire ewes and several lambs. I tried every precaution I knew of, such as not turning out until late in the morning, having them well filled with hay and grain, but it seemed to make no difference. Some days there would be no losses; then would come a day when a dozen would die after they had been grazing four or five hours.

My opinion is that if one had a dog and coyote proof fence around the pasture and kept the sheep on night and day and kept the alfalfa picked down close until they got accustomed to it, the loss would not be so large.

However, from what I have been able to learn from



those who have had more experience than myself, they suffer from 15 to 25 per cent. loss, which at the present high price of ewes is rather expensive.

---

WM. and H. G. GREENE, Olney.

Our late lambs began to come about the tenth of April, and both in 1897 and in 1898 we lambed them on alfalfa. We put the ewes on the alfalfa before it started and kept them there until we were through lambing. We yarded them at night. Until the alfalfa got well grown we fed them hay. When feed began to get plenty, they would bloat more or less, but we never lost a sheep.

The first season after the lambs were a few days old we tried returning the ewes to the alfalfa. But we could not make it work. The ewes would bloat and die, if they were only on for a short time, even fifteen to twenty minutes. Last year we did not try to return the ewes to the alfalfa after they came in, but took them to the prairie which was good feed. By running the dropping band on alfalfa, the ewes have plenty of milk and are in good condition. We expect to run the dropping band in 1899 the same way. We have fine lambs and expect to get nearly one hundred per cent. increase. We have tried other ways of running sheep on alfalfa but cannot make a success of it.

---

D. C. ROBERTS, Ordway.

My experience in pasturing alfalfa with sheep is on rather a small scale. Among my sheep that I was fattening during the spring of 1898, were eight ewes that dropped lambs in April—fifteen lambs from the eight ewes—while on dry feed in the corral. When I sold my sheep in May, these ewes and lambs were turned loose in the alfalfa fields, twenty-three head in all. They roamed over the farm at their own will, seldom coming near the barn. In September I put them in the corral again and found there were twenty-three head still. On September 10, several of the larger lambs weighed 80 to 90 pounds. They were on the green alfalfa through wet and dry and apparently never bloated.

---

S. McCARTA, Manzanola.

In October 1896, I bought my first bunch of sheep. I

got them home about two o'clock in the afternoon, turned them into an alfalfa field, went on to the house and paid no attention to them except to look from the house and see if they were still in the field. About sundown I turned them into the corral. I thought they looked full, but never thought of bloat, as the party from whom I bought them assured me there was no danger in pasturing on alfalfa. The next morning I turned them into the same field, and continued this practice as long as there was anything in the field to eat, in fact nearly all winter. The alfalfa was nearly a foot high when I turned them in and they were very hungry, for I had driven them thirty miles during the day and a half, and they had had little to eat or drink. This was my first experience in pasturing sheep on alfalfa and I never lost a single one. By the fall of 1897 I had received the advice from all the know-alls in the sheep business. I was warned never to let the sheep on to the alfalfa unless they were well filled up with feed and water, also especially never to turn sheep on alfalfa early in the morning.

I adhered to both of these rules until I lost about forty-five ewes. The last loss was sixteen in less time than it takes to write it. They came off of a hill pasture where they had been all day. This was at four o'clock in the afternoon. Before half-past four they were tumbling in every direction.

The next morning early I opened the gate from the corral and let them into the alfalfa field. Then I told my man not to go near them and I went away for the day, and at night they were all right with not a single loss. After that I continued to shut them up late at night and turn them out early and lost no more from that bunch.

A few weeks later I bought another bunch of 600 ewes. I filled them up well on hay and corn for about a week. Then about the middle of one afternoon I turned them into the alfalfa. In half an hour I had lost nine head. The next morning I turned them out at daylight and lost no more. In all these cases there was plenty of water in all the fields.

In the spring of 1898 I had about 900 ewes to lamb. Five hundred of them were in one bunch in a corral at one corner of a fifty acre alfalfa field. Early in the morning we opened the corral gate and filled the racks with hay so that the sheep could roam over the field or stay and eat hay if they preferred. This was begun before the alfalfa started. It was kept up until the middle of May by which time the alfalfa was a foot high. Then as we needed the alfalfa for



hay we turned the sheep on the range. In all this time we lost only one sheep and it is not sure that this one died of bloat. We were very careful not to drive or bother this bunch of sheep. When they had all gathered in the corral at night the gate was closed and opened again very early in the morning.

The other 400 ewes had no alfalfa field so convenient to their night corral and they had to be both driven and herded. We had almost daily losses with this bunch until finally we made some new fencing that allowed them to roam without herding and after that our losses ceased.

In the light of these three season's experience, it seems to me that if a person wants to make a success of pasturing alfalfa and is so situated that he must corral the sheep at night, then this corral should be in the field where there will be no need ever to drive the sheep or worry them.

In the fall of 1898 I took sheep off the cars and turned them at once into an alfalfa field that had been cut but once during the season and where the alfalfa was so high the sheep could hardly be seen. Yet there were no losses.

In regard to the profit of thus pasturing alfalfa; I have made a little money at it and I believe there is money in it for anyone who has sufficient land and capital so that he can arrange matters properly.

---

W. B. BALDWIN, Fowler.

We have had considerable experience in pasturing sheep on alfalfa. At first we lost quite a number, but finally found that the loss would be largely reduced if we left the sheep on the alfalfa day and night and kept the alfalfa large. We also found it best to have the sheep's stomach empty when put on alfalfa and then not take them out even if they do bloat. Our theory is that if the stomach is empty there will be room for a large amount of gas if they do bloat, and as soon as they begin bloating they will stop eating and but few will die. This theory is altogether different from the general opinion, but it is all right. Sheep must not change pasture. They must stay on the same pasture all summer if you wish to have success. Good alfalfa will keep about eight ewes and their lambs per acre. It should be irrigated often so as to keep the alfalfa from getting dry. If the alfalfa should get dry and you have to change the sheep to another field, you may expect losses.

Shropshires are the hardiest sheep I have had on pasture or on range.

Lambs do not bloat on alfalfa pasture until they are old enough to wean.

Alfalfa is certainly the best thing to lamb on for spring lambs. We are now (January 1899) having our first experience in lambing ewes in the winter. We have 1100 ewes and so far have saved about ninety-five per cent. of the lambs.

---

W. H. NEY, Fowler.

The best way to guard against bloat in pasturing sheep on alfalfa is to feed the sheep well on any dry feed just before turning them on the alfalfa and turn them in while full and leave them there night and day. By this method the losses will be light and success assured. Alfalfa pasture has great fattening qualities and early lambs having the run of alfalfa fields during the summer months will make much heavier gains than lambs running on the open range and depending on native grass. We could show lambs the fall of 1898 that were fit for any market and had tasted no grain since the last April. Sheep that run on alfalfa need little or no grain to fit them for market and this makes quite a saving.

The Arkansas valley is well adapted to sheep farming. Hay is cheap for winter feeding and the necessary grain can be raised here as cheaply as anywhere. For either breeding or fattening sheep I know of no place to equal the Arkansas Valley.

---

J. W. BROWN, Rocky Ford.

This is our first year of pasturing sheep on alfalfa. We pastured 500 ewes and their lambs on alfalfa for two months and then turned them on the range. We did not lose any by bloat. We did not move the sheep off the alfalfa when we irrigated. We have a large breed of sheep, the French Merinos, the ewes weighing from 140 to 200 pounds. We lamb early, feed for awhile in the corrals and this year we pastured on alfalfa for two months. This gives both the ewes and the lambs a good start and they do well on the range. We expect our lambs to weigh 90 pounds the first of October. Alfalfa is all right for sheep.

---

T. N. ORCUTT, Rocky Ford.

I have never pastured on alfalfa, but make it into hay



and feed the year around. I now have only pure bred Cotswold sheep at the home farm. I have two pastures, one of rye and one of blue grass; while one is growing they eat the other.

Alfalfa is not used for pasture for sheep in this section at all. Where it has been tried the losses were heavy. I understand that some feeders think they can afford to lose 5 to 10 per cent. This may do for toothless ewes, but my registered sheep are too valuable to take the risk. One of my neighbors put 1,500 sheep on alfalfa and I understand lost as high as sixteen in one day. Another tried it this spring, but the losses were so heavy he abandoned it. Near Las Animas they succeeded better, but here the alfalfa grows too rank.

---

**A. FORDER, Rocky Ford.**

I pastured one year 1200 ewes and their lambs on alfalfa for thirty days without any losses, then changed pastures and lost 75 ewes in about ten days, then changed to the range and will not try alfalfa pasture again. We did not irrigate the land while the sheep were there.

I have pastured old ewes and lambs on alfalfa after it stopped growing in the fall and did not lose any by bloat. We fed corn at the same time and the sheep did well.

---

**J. P. STEVENSON, Rocky Ford.**

I have tried for several years to run sheep on alfalfa; the result has been disastrous every time. Some four or five years ago I bought a bunch of New Mexican lambs, put them at first on very short alfalfa and kept them there for several days, then put them on better alfalfa. They commenced to bloat and before I took them out I lost 65 head. I had at the time a bunch of 300 native ewes. I put them on the same ground and gave them the same treatment and never lost one. The next spring these ewes were turned on the alfalfa as soon as it appeared green, but as soon as it got some growth they commenced to die and I had to remove them to native grass. I lost from one to four every day. Last fall I again bought 300 well bred Shropshire ewes. I put them on good alfalfa the first day I got them home and kept them there until night. I did not lose one. Next morning put them on again after dew was dry and kept them on all day; lost one. The third day I waited

until grass was dry and then put them on again. By noon I had lost nine head.

This spring I have kept the ewes up, fed them hay and let the lambs run through the fence and graze the alfalfa. They have done fairly well, but I believe if they and the ewes had other green grass and plenty of it as they do on alfalfa, that they would do better than on alfalfa. I have noticed one thing, that these lambs will leave the green alfalfa for dry hay and for a patch of wild grass. Still I have good lambs; some few January and February lambs weighed the middle of June 80 to 90 pounds.

All my sheep were turned on the range in June and I will bring them back the middle of August. Lambs dropped in April and fed as above ought to weigh 70 pounds the first of September.

My experience with pasturing sheep on alfalfa for six years has cost me several hundred dollars on account of bloat and that, too, with only a small bunch of 300 to 500 ewes.

I do not think I shall ever graze sheep on it again. The sooner the farmer who wants to graze his breeding stock on green feed gets something in place of alfalfa the better off he will be. People who have been buying old ewes at 75 cents to \$1.00 per head and putting them on alfalfa have not lost much money if they lose ten per cent. of their ewes. But where the ewes are worth four to six dollars per head the case is quite different.

But although pasturing alfalfa has not been a success yet the sheep business, as a whole, has been profitable. This Arkansas Valley is a wonderful place for sheep. Our 1898 account stands as follows :

We had 35 lambs dropped in February and about 250 dropped in April and May. They went to the range June 10 and came back early in August. We commenced feeding bran and oats August 15 and got them on to full feed about the last of September, by which time they were eating one and three-fourths pounds of shelled corn per head per day. The latter part of October we sold 50 picked ram lambs at \$10 per head. Fifteen of these came in February and the rest in April. Their average age was about seven months and they weighed 99 pounds per head. During November we sold 20 more ram lambs for \$10 each. In December sold 40 ram lambs for \$5 each. This left us 18 cull ram lambs. These 18 with 118 ewe lambs we took to Kansas City the last of December and after an extra hard trip they weighed 81½ pounds and sold for \$5.40 per hun-



dred pounds or \$4.40 per head. We had, therefore, total receipts of almost exactly \$1500.00 from 246 lambs. We consider this a good showing.

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JOSEPH CARL, La Junta.

We are pasturing 425 ewes and lambs on alfalfa the season of 1898. They have the run of twenty acres of alfalfa and up to June 8th, we have lost only one sheep by bloat. This is our first trial of pasturing sheep on alfalfa and so far we are well pleased with it and shall go into it on a larger scale next year.

---

S. H. POLLOCK, La Junta.

I undertook to pasture about 300 ewes and 225 lambs on alfalfa pasture, by feeding them well on corn and hay before turning them on the alfalfa and then leaving them there day and night. I left them three days and lost three ewes. I then gave it up and put them on the range.

---

GEO. W. PARKER, La Junta.

I have pastured sheep on alfalfa for three or four years and have lost on the average possibly two per cent by bloat. A good acre of alfalfa will support ten ewes and their lambs all summer. We turned the sheep off the land when we irrigated it. A cross bred Shropshire and Merino lamb pastured on alfalfa ought to weigh 75 to 80 pounds, the first of October. From my experience, more especially with old ewes, I think well of lambing on alfalfa when the grass is short on the range and would especially recommend keeping the breeding ewes on the farm and feeding them nice green alfalfa hay before lambing instead of wintering them on the range.

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R. A. McKIBBON, Lamar.

We run a few ewes, about fifty, on a small patch of eight acres of alfalfa. We have the lot divided and put the sheep in one while we irrigate the other. This is the second year we have tried it. We have lost two old ewes by bloat. We expect our spring lambs to weigh 75 pounds by the first of October. The season of 1898, we also lost a lamb by bloating.

## G. W. MAY, Lamar.

During 1897 we pastured 1,000 ewes on 80 acres of alfalfa. This was our first year's experience and we lost nine per cent with bloat. We left the sheep on the land when we irrigated it. We began pasturing in April and by the middle of July the 80 acres proved not enough and we got 15 acres more. Even the 95 acres did not keep them and about the first of August we turned them onto the range. In 1898 we started with 160 acres, but by the middle of August the alfalfa was all gone and we had to turn them onto the range.

My belief is that not over 100 head of ewes should be pastured in one bunch on alfalfa and that at the rate of five ewes and their lambs to the acre. For larger bunches, if the alfalfa pasture was free of cost, it would be dear to use it on account of the great loss by bloat.

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## GEO. W. WILSON, Lamar.

We had several thousand ewes on alfalfa for forty days during the spring of 1898. Part of the time we kept them on day and night; part of the time they were corralled at night and turned out after the dew had dried off in the morning. Both plans were failures so far as preventing bloat was concerning and after losing about five per cent by bloat in the forty days, we gave it up and sent them to the range. I have satisfied myself that pasturing on alfalfa in the Arkansas valley is not practicable at least with large bunches much as I should like to have had it otherwise. At the same time I consider it the best district in any country for raising and feeding lambs.

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## JOHN McNAUGHT, Las Animas.

Have pastured sheep on alfalfa for six years. Fifty acres of good alfalfa will support about 500 ewes and their lambs the whole season. In different years we have lost from eight to ten per cent by bloat. We do not move the sheep off the alfalfa when we irrigate it. We undertake to give plenty of pasture at the start and then not move them. Our May lambs we expect to weigh about 60 pounds the first of October. We fatten our own lambs.

[NOTE—The present writer visited Mr. McNaught, July 14th, 1898 and saw his 500 ewes and their lambs on alfalfa. These were all old ewes, nearly toothless, which is



the reason for keeping them at home instead of sending them out on the range. The number lost to date by bloat was fifteen or three per cent. They had some forty acres of alfalfa to run on and were not keeping it at all close. Quite a share of those lost had been when some overflow water ran into one corner of the field. Mr. McNaught says that if the whole field had been irrigated, there would have been less danger of bloating than with merely a single spot. Mr. McNaught's doctrine in regard to pasturing sheep on alfalfa is never to let them get hungry. The best way is to have the fence coyote tight, but if this cannot be done, then corral them at night as he is doing this summer and let them out early in the morning.]

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PURVIS BROS., Las Animas.

During the summers of 1897 and 1898 the grass was so good on the range that, as a general thing, it paid to run sheep on the range. Indeed, under these conditions of an abundance of fine grass, the lambs are almost as good as those pastured on alfalfa and the expense is less.

We had only about a hundred sheep on alfalfa during the summer of 1898. They did quite well. We had them, their lambs and ten horses on a twenty acre pasture and we could almost have cut it for hay. When the lambs were weaned the ewes were nearly fat enough for market.

The cause of the greatest loss from bloat is probably the necessity of corralling at night on account of coyotes. Where this plan is practiced the sheep should not be put into the corral until almost dark and turned out in the morning before daylight. The sheep generally bloat in the evening and this is due most likely to the practice of leaving them in the corral too late in the morning. Some actually put them in the corral at 4 o'clock in the afternoon, thinking to avoid the loss, as it is after this time that they generally bloat, and then leave them shut up until after the dew is off in the morning. This makes about sixteen hours in the corral and only eight hours on feed, consequently the sheep do not do well.

This year, 1898, was the fourth season for us of pasturing alfalfa with sheep. On the average we have lost about five per cent. with bloat. We have the field divided into two parts and pasture one while we irrigate the other. These were old ewes and were pastured all summer. We expect alfalfa fed lambs to weigh about 75 pounds the first of October.

[When on a visit to the Arkansas Valley in July the

present writer learned that Purvis Brothers have their fences coyote tight and do not have to bother about corraling the sheep at night. To still further lessen the danger from coyotes, they had taken to hunting them with greyhounds and had killed seventeen so far during the season.

To surround a whole farm with coyote tight fence would be rather expensive, but it would not cost much to fence five acres and drive the sheep in there at night, thus diminishing the danger from bloat.]

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CHRISTIAN MARLMAN, Las Animas.

Pastured 470 ewes and their lambs on alfalfa during May and June 1898. They ran on about fifty acres of alfalfa. They were turned onto the range June 11 and remained there until the latter part of September. Lost in all about three per cent. by bloat. They ate all the first cutting, so that it cost us one-third of our hay crop. These lambs were dropped in March and weighed between 50 and 60 pounds when brought back from the range. We are well satisfied with the result and shall try it again next season.

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JOHN E. DONLON, Las Animas.

In 1896 we pastured 1200 ewes with their lambs on 160 acres of alfalfa and lost about eight per cent. by bloat. That year we fed no grain. In 1897 we fed 1,000 ewes and their lambs on the same field. This second year we fed corn chop to the sheep and lost only 2 per cent. by bloat. Both these years we had aged ewes and kept them on the field all the time, even when we irrigated it. We would not risk young ewes on alfalfa. In 1898 we have had such excellent feed on the prairie that we kept our sheep on the range most of the season.

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A. M. LAMBRIGHT, Las Animas.

During 1897 we pastured 750 ewes and their lambs on 100 acres of alfalfa and lost about three per cent by bloat. We kept them on the land the entire season, not changing when the land was irrigated.

In the spring of 1898 we started 1,000 ewes on 160 acres of alfalfa, but the feed on the range was so good that we turned them onto the range the latter part of May. If we



had kept them on the farm all the season, I think 130 acres would have been sufficient to feed them.

There have not been very many raising lambs here and what has been done has been done for only a couple of years. We have run simply old ewes on alfalfa so that the test so far as bloat is concerned is hardly a fair one for sheep raising in general. I am sure that old ewes do not bloat so much as young ones. Most of us have not invested in enough for fences to cut our pastures up properly. I think that if we had our pastures fenced so that there would be no danger from coyotes and would leave the sheep on the land all the time, there would be comparatively little danger from bloat if the owner would go around through them a couple of times a day and make them get up and eat a little. Some lost considerable here this year and have been scared out to the range. We have only lost three out of 1,000. Of this 1,000, not over one-third could be classed as old ewes. I have very little doubt but that there is a difference in size in an alfalfa fed lamb and one raised on the range of at least twenty-five pounds. The chances are that we could afford to raise nearer pure bred Shropshire or Hampshire Downs on ranches than we could afford to do on the range (for it is generally supposed here that none but Merinos or Mexican Improved with Merinos will herd on the range), and if this is done we can make a difference of at least fifty pounds.

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#### SCOTT BROTHERS, Las Animas.

In 1898 our sheep are all on the range, the grass is so good.

A good stand of alfalfa will carry ten ewes and their lambs per acre the first year; the next year fewer and the next year still fewer.

Pasturing alfalfa by sheep is hard on the stand, as they bite out the crowns of the plant. We pastured sheep on alfalfa for one whole season and during the fall for three years. When pasturing the whole season we lost about five per cent. by bloat. We are very careful to leave them on the alfalfa all the time after they are once placed there, never changing them when the field is irrigated. Grade Shropshire lambs to which we had fed corn while on alfalfa weighed 75 pounds the first of October. Our grade Mexican lambs weighed 70 pounds. If we had not fed corn they would probably have weighed 5 to 10 pounds less. We fatten our own lambs.

**JACOB WEIL, Las Animas.**

During 1898 we did not pasture sheep on alfalfa, but have done so on two previous years. We were in the habit of taking them off the field when it was irrigated. Our lambs weighed about 65 pounds the first of October and we fattened them on the farm.

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**F. T. WIBBER, Fredonia.**

We have pastured sheep on alfalfa for five years. The first year we lost ten per cent. Now we do not expect to lose any. We do not move the sheep when we irrigate. In 1898 we pastured 500 ewes and their lambs on 160 acres of alfalfa from early in the season until the first of July. They were then turned on the range and stayed there until fall. We expect lambs so treated to weigh 70 pounds the first of October. We fatten our own lambs.

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**A. F. KLINKERMAN, Fredonia.**

We have pastured sheep on alfalfa part or all of three seasons. One season we lost as high as ten per cent. by bloat, but this was due largely to inexperience. During 1898 we let the ewes run on alfalfa during the six weeks of the lambing season and as soon as that was over we sent them to the range. We lost about one per cent. during the six weeks. We had about 500 ewes and their lambs on 50 acres of alfalfa. We have always left the sheep on the land when irrigating it. We expect May lambs to weigh 60 pounds the first of October if pastured on alfalfa. In 1898 we turned the ewes and lambs on the range the first of June. It probably took two-thirds of the first cutting of alfalfa to lamb the sheep on it, but we consider ourselves well paid in saving of lambs and the start it gave them and the old ewes before turning them on the range. We are satisfied that we saved at least fifteen per cent. more lambs than could be done on the range and also saved in the expenses of herders during lambing.

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**L. M. CAMPBELL, Fredonia.**

We feed on alfalfa exclusively, no grain except to lambs born in the winter.

First make a fence with posts 10 feet apart, nine barbed



wires, stretched tight,  $4\frac{1}{2}$  feet high. This will turn a wolf or a dog and is the principal essential of running sheep on alfalfa pasture, since they must have free access to the feed day and night. Shade, salt and water are very essential. Have the sheep entirely free from hunger or thirst before turning them on the alfalfa.

In December, 1895, I bought off the range 100 ewes, each with a lamb by its side. They did well until the alfalfa started in the spring. Then we attempted to herd them on the alfalfa in the day time and corral them at night. Our loss by bloat in ten days was 12 ewes and 15 lambs. We put them on native grass for a few days until we could build such a fence as I have described. We enclosed 10 acres of alfalfa and 5 acres of timber. This was in April, 1896. I drove them over a wheat field to the alfalfa pasture to be sure they were full. I have not lost a sheep or lamb since then by bloat and I have no fear of ever losing one.

I have yet five head—four ewes and one buck—of the first 100 bought and they have never been out of that enclosure. The ewes are nine years old, the buck a few years older, and their teeth are as good as the average six-year-old on the range. We never take the buck away from the ewes.

Two of the four ewes had twins last November and the same ewes had twins again this year (1898) in May. The four November lambs weighed in the middle of June 70 pounds each, while the May lambs weighed at the same time twenty pounds each.

We wintered 85 ewes in that pasture during 1897-98 and raised in the spring of 1898 135 lambs, forty of which—the wether lambs—we sold in Kansas City in April, where they averaged 60 pounds and brought  $6\frac{1}{2}$  cents per pound, or \$3.95 cents per head. The ewes sheared about  $7\frac{1}{2}$  pounds of wool apiece.

I think my pasture would support quite a number more sheep than we have on it, or about ten ewes and their lambs per acre. We irrigate with the sheep in the pasture and can see no bad effects. I do not advocate close pasturing. We have never fattened any lambs, selling them when they are three months old.

Sheep do their principal feeding at night. It would not be profitable to corral sheep at night when in alfalfa pasture, even if it were not for bloating. They will do much better when they can have access to feed both day and night.

Alfalfa pasture does not seem to be favorable to scab.

We bought our sheep from a herd that was infested and expected to dip, but so far have had no occasion.

I am a strong believer in pasturing as a method of handling our alfalfa. Conducted on the principles here described there is nothing in my judgment more profitable than handling sheep and I hope to see the day when every farm in Colorado will be supporting a flock of sheep.

The total income from these 87 ewes for the year from November 1897 to 1898 is as follows:

|                                                              |          |
|--------------------------------------------------------------|----------|
| 40 wether lambs sold in April @ \$3.95..                     | \$158.00 |
| 640 pounds wool from ewes @ 10c.....                         | 64.00    |
| 175 pounds wool from lambs @ 14c.....                        | 24.50    |
| 35 ewe lambs saved for breeding @ \$3.50.                    | 122.50   |
| 52 lambs for market, 75 lbs. each, November 1, @ \$3.00..... | 156.00   |
|                                                              | <hr/>    |
|                                                              | \$525.00 |

Year's income per ewe \$6.04.

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### IS PASTURING ALFALFA PROFITABLE.

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It will be noticed from the foregoing letters that the pasturing of alfalfa by sheep is used for several purposes; sometimes for only a few weeks in the spring while the ewes are lambing; sometimes for very early lambs to fit them for the summer market; more commonly for old ewes that would not thrive on the range and by some as a regular way of keeping sheep.

It will also be noticed that there are certain things about which all are agreed. By inference we may judge that all agree, that for keeping wethers or ewes without lambs, alfalfa pasture cannot compete with the open range. This is undoubtedly true so that the only profitable use for alfalfa pasture is as feed for ewes with lambs.

It is also evident at the outset that alfalfa pasture is not cheap feed, not nearly so cheap as the range. If then it is to be used in competition with the range it must be because more growth is obtained on the lambs when on alfalfa than when roaming the range.

The question of raising early lambs on alfalfa and other feeds will be discussed in the latter part of this bulletin.



Here we are to consider the pasturing of lambs during the whole summer that are to be fattened on the same farm during the fall and winter for the eastern markets.

The practical question is, can this be done with as much profit as to range the lambs through the summer and then bring them to the farm for winter feeding. To the feeder of the Arkansas Valley at the present time, this is the simple proposition. But the time will come when the problem will present itself in another form. In the feeding districts of Northern Colorado that time has already come and the problem as it will appear in the future is this: There is or will be on the farm a certain amount of alfalfa. By which method can I realize the more profit, by making hay of it and feeding it to lambs in the winter or by using part of it as pasture for ewes and lambs during the summer and the rest to support the ewes during the winter?

The average of the statements from the various individuals seems to be about ten ewes and their lambs to one acre of good alfalfa pasture, running on the land from the middle of April until the first of October. This would require very good alfalfa and it is probable that eight ewes to the acre would be nearer average conditions. The ewes would feed on the stubble fields practically without cost during October and November, leaving four and a half months that they would have to be hay fed.

A full grown ewe will eat five pounds of hay per day or two and three-fourth tons of hay to run the eight ewes through the winter. If we estimate an acre to produce four tons of alfalfa, then it would require three-fourths of an acre to supply hay for the winter and one acre to pasture them during the summer.

What return could be expected as the income from this acre and three-fourths of alfalfa? For the last four years lambs have averaged being worth four cents a pound live weight on the farm the first of October. It is fair to presume that a person who was planning for pasturing alfalfa would have the lambs dropped in March and they ought then to weigh 70 pounds the first of October and be worth \$2.80 each. The ewes would need to be fed grain for sixty days, one pound per day, costing in all forty cents for each ewe. The ewes should shear seven pounds of wool each, worth at least ten cents per pound.

The whole account would stand thus:

## Income.

|                           |         |
|---------------------------|---------|
| 8 lambs @ \$2.80.....     | \$22.40 |
| 56 pounds wool @ 10c..... | 5.60    |
| Total .....               | \$28.00 |

## Expenses.

|                       |         |
|-----------------------|---------|
| 480 pounds grain..... | \$ 3.20 |
| Difference .....      | \$24.80 |

This difference of \$24.80 represents the return from the land that will produce seven tons of alfalfa or about \$3.50 per ton for cutting and feeding about half the alfalfa and letting the sheep harvest the other half.

Out of this return would need to be deducted the interest on the investment and any losses by bloat that may occur.

Whether or not any greater return for the alfalfa can be obtained in any other way, each farmer will need to answer for himself. It is believed that the items of income as given above are conservative estimates and that profits much larger than this would often be obtained.

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## IS PASTURING ALFALFA SAFE.

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The answer must be given in the negative. But in view of the statements given by some of those who have had the most experience, the danger from bloat can be largely overcome and the loss reduced to at least not more than five per cent.

On the basis of the estimates already given, a five per cent loss by bloat would reduce the returns for the alfalfa fifteen cents per ton. If there is any profit in pasturing alfalfa, a five per cent. loss on the ewes would not reduce the profit to any serious extent.

There seem to be certain precautions that need to be observed in pasturing alfalfa to prevent bloat and they can be summarized as follows:

1. Have the sheep in small bunches, or if in a large bunch divide into several lots in separate fields.



2. Have a large enough field to supply them with an abundance of food with little effort.

3. Leave them in the field day and night and do not remove them when the field is irrigated.

4. Have water and salt before them all the time and if there are no trees in the field provide some sort of shelter against the sun.

5. Be sure they are filled up with some other food and not thirsty when first turned on the alfalfa.

6. Do not attempt to pasture on alfalfa anything but old ewes and their lambs.

It is probable that by following out the above directions the losses by bloat with old ewes can be reduced to less than five per cent.



## II. RAISING EARLY LAMBS.

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BY W. W. COOKE.

For many years there have been a few early lambs raised in Colorado. The large markets for early lambs—Chicago, New York and Boston—are so distant that Colorado can hardly hope to compete with the eastern states in supplying lambs in the spring to these cities. Kansas City and Omaha are near enough to be reached, but they are never able to handle very many lambs at one time and their total demand for early lambs is not large. The local market in Colorado is still more limited. It is evident, then, that not many people in Colorado can profitably engage in the raising of early lambs. But there is always a demand for some of these lambs and some one has to supply that demand. At the present time the attention of Colorado feeders is turned more particularly to the feeding of lambs raised in the south and west, because for them the market is almost unlimited and they can be handled by the thousands. The object of the present inquiry was to learn whether the small farmer can raise early lambs and realize as much for his labor and feed as his neighbor with the larger farm does with the older lambs.

During the summer of 1895 fifty ewes were purchased for the test. Half were grades of the Shropshire crossed onto the Merino, and the other half were Horned Dorset and Merino. They were a fine lot of ewes, all of them three years old, having dropped their second lamb the spring of 1895. They cost three dollars per head. Fifteen of the Shropshire ewes were served by registered Shropshire bucks, the other ten by registered Dorset bucks. Fifteen of the Dorset ewes were served by the Dorset bucks the other ten by Shropshire bucks. The lambs were dropped during January and February of 1896.

The fifteen Shropshire ewes that were served by Shropshire bucks dropped 14 lambs, of which 11 were buck lambs and 3 ewe lambs. The ten Shropshire ewes served by Dorset bucks dropped 13 lambs, 5 bucks and 8 ewes. The fifteen Dorset ewes served by Dorset bucks dropped 20 lambs, 16



bucks and 4 ewes. The ten Dorset ewes served by Shropshire bucks dropped 9 lambs, 5 bucks and 4 ewes.

To make the comparison a little easier to see, the above figures have been reduced to the basis of 100 ewes and give the following results:

|                                                             | Lambs. | Sets of<br>Twins. |
|-------------------------------------------------------------|--------|-------------------|
| 100 Shropshire ewes served by Shropshire bucks dropped..... | 94     | 7                 |
| 100 Shropshire ewes served by Dorset bucks dropped.....     | 130    | 40                |
| 100 Dorset ewes served by Dorset bucks dropped .....        | 134    | 33                |
| 100 Dorset ewes served by Shropshire bucks dropped .....    | 90     | 0                 |

Figured from the side of the ewe, 200 Shropshire ewes, half served by Shropshire bucks and half by Dorset bucks produced 224 lambs with 47 sets of twins. 200 Dorset ewes, with the same service produced 224 lambs with 33 sets of twins. Figuring from the side of the buck, 200 ewes, half Shropshire and half Dorset and all served by Shropshire bucks, produced 184 lambs with 7 sets of twins. 200 ewes, the same but served by Dorset bucks produced 264 lambs with 73 sets of twins.

It is evident from these last sets of comparisons that the prepotency toward the production of twins lay with the bucks and not with the ewes. It is generally conceded that the Dorset is one of the most prolific sheep and the bucks ought to have had this quality more pronounced for they were pure bred while the ewes were grades.

So far everything seemed to favor the Dorsets as the more profitable sheep. But these lambs were dropped in the middle of winter and the twins did not seem to have the vigor to stand cold weather so well as those that had been born singly. Moreover the ewes seemed to be able to give an abundance of milk for one lamb but not enough for two.

The ewes were given grain, and a lamb creep was provided where cracked grain was kept all the time. The lambs learned to eat grain before they were a month old and after that, ate nearly as much as the ewes. Yet in spite of this the twin lambs did not do so well as the others and those that we lost were almost entirely from the twins.

We began selling March 10 and sent off the last May 21. The price was 15 cents per pound dressed weight.

The four sets of lambs of different parentage gave the following results:

Record for the Spring of 1896.

| Dam.....             | Sire.....   | No. of Lambs. | Average Date of Birth. | Average Date of Sale. | Age in Days at Time of Sale. | Live Weight. Pounds. | Dressed Weight. Pounds. | Selling Price Per Head. |
|----------------------|-------------|---------------|------------------------|-----------------------|------------------------------|----------------------|-------------------------|-------------------------|
| Shropshire           | Shropshire  | 13            | Feb. 1                 | April 20              | 79                           | 47                   | 22                      | \$3.30                  |
| "                    | Dorset..... | 10            | " 3                    | " 25                  | 82                           | 48                   | 22                      | 3.30                    |
| Dorset.....          | Dorset..... | 15            | " 9                    | " 16                  | 67                           | 47                   | 22                      | 3.30                    |
| " . . .              | Shropshire  | 9             | Jan. 22                | " 3                   | 72                           | 51                   | 23                      | 3.45                    |
| Total and Average... |             | 47            | Feb. 1                 | April 16              | 74                           | 48                   | 22                      | \$3.30                  |

The reason that the dressed weights are so nearly equal, is that we sold from week to week, selecting the lambs as soon as they were large enough to dress over twenty pounds. We finally sold 47 lambs from the 50 ewes, of which 25 came from the twenty-five ewes that were served by Dorset bucks, while 22 were from the twenty-five ewes served by Shropshire bucks.

In the matter of rapidity of growth the ewe seemed to be the controlling factor, rather than the buck as might naturally have been expected. The lambs from Dorset ewes dressed 22 pounds by the time they were 69 days old, averaging 49 pounds live weight, while the lambs from Shropshire ewes required eleven days longer to reach the same weight.

Taking the whole experiment through, the Dorset ewes served by Dorset bucks gave the best results, giving us fifteen lambs from fifteen ewes that sold for \$3.30 per head at 67 days old.

The average for all classes is January 30 for date of birth and April 16 for the date of sale when they were 77 days old, weighed 48 pounds alive, 22 pounds dressed and sold for \$3.30 at the farm.

As fast as the lambs were sold the ewes were taken off from grain and when the last lambs were gone, the ewes were sheared and turned out to pasture on native grass until the next winter.

The same method of procedure was adopted in 1897, except that as the lambs were dropped a little earlier, they were allowed to grow a little larger before they were sold.

This season all the ewes were served by Shropshire bucks and though the lambs sold are one more than 1896, the difference in favor of the Dorsets is larger than in 1896.



There are 21 lambs credited to the Shropshires. One more lamb was dropped but so late in the season that it could not be sold with the others in the spring and was carried over until the next season. It is counted in the summary as worth \$2.00, though of course we actually received more than that for it at the time of sale.

The record for the spring of 1897 is as follows.

Record for the Spring of 1897.

| DAM.                    | No. of Lambs Sold | Average Date of Birth. | Average Date of Sale. | Age at Date of Sale, Days. | Live Weight, Lbs. | Dressed Weight, Lbs. | Selling Price. |
|-------------------------|-------------------|------------------------|-----------------------|----------------------------|-------------------|----------------------|----------------|
| Shropshire .....        | 21                | Jan. 15                | March 27              | 71                         | 54                | 27                   | \$4.05.        |
| Dorset .....            | 27                | Jan. 12                | April 2               | 80                         | 56                | 26                   | 3.90.          |
| Total and Average ..... | 48                | Jan. 13                | March 30              | 76                         | 55                | 26.5                 | \$3.97         |

Again for the third year the same experiment was repeated. The ewes were all served by Shropshire bucks, but were getting so old that several did not lamb the spring of 1898.

Instead of selling the lambs for slaughter they were all sold April 13 at \$3.50 per head for breeding purposes. This was about the price they would have brought if they had been fed a little more grain and sold for meat.

The following is the record for the spring of 1898:

Record for the Spring of 1898.

| DAM.                 | No. of Lambs Sold | Average Date of Birth. | Date of Sale. | Age at Date of Sale, Days. | Live Weight. | Selling Price |
|----------------------|-------------------|------------------------|---------------|----------------------------|--------------|---------------|
| Shropshire .....     | 17                | Jan. 1                 | April 13      | 102                        | 61           | \$3.60        |
| Dorset .....         | 23                | Dec. 25                | April 13      | 109                        | 59           | 3.40          |
| Total and Average .. | 40                | Dec. 28                | April 13      | 106                        | 60           | \$3.50        |

This closed the experiment. The total records for the three years will be considered first with reference to the two breeds, the Shropshire and the Horned Dorset. Then it will be treated as a whole with reference to the financial side of the question.

### Shropshires.

| Year.      | No. of Lambs Sold. | Age in Days at Date of Sale. | Live Weight. | Dressed Weight. | Selling Price Per Head. | Total Selling Price. |
|------------|--------------------|------------------------------|--------------|-----------------|-------------------------|----------------------|
| 1896       | 23                 | 80                           | 47           | 22              | \$3.30                  | \$75.90              |
| 1897       | 21                 | 71                           | 54           | 27              | 4.05                    | 87.05                |
| 1898       | 17                 | 102                          | 61           |                 | 3.60                    | 61.20                |
| Total..... | 61                 | 84                           | 54           | 26              | \$3.64                  | \$224.15             |

### Horned Dorsets.

| Year.      | No. of Lambs Sold. | Age in Days at Date of Sale. | Live Weight. | Dressed Weight. | Selling Price Per Head. | Total Selling Price. |
|------------|--------------------|------------------------------|--------------|-----------------|-------------------------|----------------------|
| 1896       | 24                 | 69                           | 49           | 22              | \$3.30                  | \$ 80.55             |
| 1897       | 27                 | 80                           | 56           | 26              | 3 90                    | 105.30               |
| 1898       | 23                 | 109                          | 59           | ..              | 3.40                    | 78.20                |
| Total..... | 74                 | 86                           | 55           | 25              | \$3.57                  | \$264.05             |

The financial results are in favor of the Horned Dorsets. The first year they grew the faster, but in both the other years the Shropshires made the most weight and sold for the most per head. But the Dorsets produced so many more lambs as to more than overbalance their slower growth. On the whole the Dorsets brought in \$40 more than the



Shropshires or about one-sixth of the total income. This difference is due entirely to the larger number of lambs reared by the Dorsets. Their record is practically one hundred per cent. since 74 lambs were sold from 25 ewes in three years.

### ARE EARLY LAMBS PROFITABLE.

It is a difficult matter to estimate the cost of running sheep in such small numbers as we had in this experiment. But we will give the income side and the winter expenses and each one can estimate for himself what the cost would be, in his own case, of carrying the ewes through the summer.

| Year.         | No. of Lambs Sold. | Age in Days at Date of Sale. | Live Weight. | Dressed Weight. | Selling Price per Head. | Total Selling Price. |
|---------------|--------------------|------------------------------|--------------|-----------------|-------------------------|----------------------|
| 1896          | 47                 | 74                           | 48           | 22              | \$3.30                  | \$156.45             |
| 1897          | 48                 | 76                           | 55           | 26.5            | 3.97                    | 192.35               |
| 1898          | 40                 | 106                          | 60           | ..              | 3.50                    | 140.00               |
| Total.....    | 135                | ..                           | ..           | ..              | ....                    | 488.80               |
| Average ..... | 45                 | 85                           | 54           | 25              | \$3.62                  | \$162.93             |

The above figures show a yearly income from fifty ewes of \$162.93 for the lambs. To this should be added the re-return for the wool. This has amounted to about 70 cents per year per head, or \$35.00 for the 50 ewes. This gives a total yearly income of \$197.93, or \$3.96 per ewe. The ewes were sold at the end of the experiment for a little more than they cost, so there was no loss in that respect.

Here are some items that can be estimated in the expense of these ewes as follows:

The ewes were kept in the corrals and fed hay after about the first of November. As soon as the lamb was dropped grain was given to the ewe and continued until the lamb was sold. When on hay alone, the ewes ate about five

pounds of hay per head per day and decreased to about four pounds when a pound of grain was added. The lambs ate a pound of hay and a pound of grain after they were 30 days old until they were sold. This makes 85 pounds of grain for each ewe and 25 pounds of grain for each lamb, or 110 pounds of grain for the ewe and lamb, costing us on an average 64 cents.

Each ewe ate 715 pounds of hay and the lamb 25 pounds or 740 pounds of hay, which at \$3.00 per ton comes to \$1.11 or a total cost for winter feed of \$1.75. Subtracting this from the income of \$3.96 leaves \$2.21 as the return for the summer feed of the ewes and the labor of caring for the sheep and lambs through the winter.

These returns compare very favorably with any that can be obtained from running sheep on the range. They represent a clear profit of at least forty per cent. on the investment. Indeed so profitable is the business that if one was sure of a market at the above prices there would be thousands and tens of thousands of early lambs raised each year in Colorado. But, as stated at the beginning of this article, the local market that pays these prices is quite limited and will buy only the very best of stock. There is money in the business for a few breeders near each of the larger cities, but if many went into the business they would break the market and themselves.

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## RAISING EARLY LAMBS IN THE ARKANSAS VALLEY.

The Arkansas Valley in Colorado is naturally tributary to Kansas City. There are more early lambs raised in the Arkansas Valley than in all the rest of the state together and most of these lambs are marketed in Kansas City, though a few are sent west to Pueblo and Colorado Springs.

The following quotations will give an idea of how the business is carried on and what returns are expected. It can be said as a preface to what follows that the early lamb business in the Arkansas Valley is founded almost entirely on the aged ewe. The old ewes that are too weak or have too poor teeth to stand another year on the range, are brought to the farm in the fall, bred to drop their lambs early, are fed heavily during the winter and spring so that by early summer they are in excellent condition for mutton and bring considerably more than could have been gotten for them fresh from the range the preceding fall. Thus there are two sources of income, the return from the lamb and the increased value of the ewe.



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WM. AND H. G. GREENE, Olney.

We raised some early lambs in 1898 that were dropped from the latter part of January to the early part of March. Our experience is that owing to the extra care and feed necessary, these early lambs are not so profitable as the later lambs.

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W. A. COLT, Manzanola.

We have been quite successful both in raising early lambs and feeding sheep on alfalfa. We breed the ewes to lamb in February and usually feed the ewe well and get her at least half fattened by lambing time. After lambing we feed the ewe all the grain she can eat and provide corn chop for the lambs. We usually have a "lamb creep" into an adjoining lot where the lamb can find corn chop and bran at any time.

As soon as the alfalfa starts we turn both ewe and lamb out during the day and provide grain and hay in the lots at night. The main point is not to compel the ewe to live entirely on the green alfalfa. There is some loss from bloat with the best of management, usually two to three per cent.

We often market the ewe and lamb in the same car, usually when the lamb is about three months old. Some, however, market the lamb and keep the ewe a few weeks and then send her in. All this class of sheep business is done with the old ewes. The ewe and lamb sometimes bring as low as five dollars, while some of our best farmers have received as high as seven dollars.

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W. H. NEY, Fowler.

During the months of January and February, 1898, we lambed 350 Shropshire ewes. These were all young ewes and of course harder to handle during lambing than older ewes. We saved over 100 per cent. of large strong lambs. The work was easier than it would have been to lamb in summer time on open range or pasture; the cost no more; a larger per cent. of lambs saved; better lambs and no loss in the ewes. The result has been entirely satisfactory to us and I can see no reason why anyone, properly prepared for it, cannot do equally well.

□ We have comfortable sheep barns with ample room for all breeding stock. We feed liberally on alfalfa with mixed grain ration of wheat and oats in sufficient quantities to keep the ewes in good condition. The lambs get grain with their mothers and appreciate it.

We have raised California Merinos and Shropshires.

The California Merinos require more care and warmer quarters than the Shropshires. The Shropshires can stand any amount of dry cold and their lambs are soon up and strong. The Merino lambs must have close attention and warm quarters, but the same attention would be necessary during the spring months and then other farm work would be crowding and prevent the expenditure of the necessary time to make a successful lambing.

When spring comes winter lambs are ready to go to the range or pasture with their mothers and will hold their own anywhere.

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**E. M. SMITH, on the farm of A. M. LAMBRIGHT, Las Animas.**

My early lambs in 1897 sold as follows: Lambs dropped in January sold in April at Kansas City for 7c per pound, live weight, and weighed  $48\frac{1}{2}$  pounds or \$3.40 per head. None of these lambs had any green alfalfa, but the ewes were turned onto the alfalfa after the lambs were sold. These ewes were sold in Kansas City in June, weighing 81 pounds, at \$3.85 or \$3.02 per head.

My March lambs sold in Kansas City in June for \$4.25 per hundred pounds and weighed 61 pounds or \$2.60 per head. These lambs were dropped in the corral and were fed alfalfa hay, corn chop and bran until March 26, when they and the ewes were turned onto alfalfa pasture and remained there until they were sold in June. We had 600 ewes and 590 lambs on 95 acres of alfalfa and with the addition of one-fourth pound of corn chop per day for a ewe and her lamb, they kept in fine shape. We commenced selling in June and sold until fall. The ewes were sold as soon as fat, some ewes going with each bunch of lambs. The April lambs in August weighed 71 pounds. In 1898 the feed on the range was so good that we pastured but little on alfalfa.

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**JOHN McNAUGHT, Las Animas.**

In 1898 I lambed 200 ewes in January and sold the lambs in Kansas City in March for 8c per pound. They weighed 53 pounds or \$4.24 per head. Two weeks later I sold the ewes for \$4.75 per hundred pounds and as they weighed 96 pounds each they brought \$4.56 per head. Neither these ewes nor lambs had any green alfalfa.

In April and May I lambed 500 ewes on alfalfa pasture. They remained there until May 26 when they were turned on the range.



Bulletin 53.

March, 1900.

# The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

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## STRAWBERRIES.

— BY —

C. S. CRANDALL and C. H. POTTER.

PUBLISHED BY THE EXPERIMENT STATION,  
Fort Collins, Colorado.  
1900.

# The Agricultural Experiment Station,

FORT COLLINS, COLORADO.

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# Strawberries.

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A prominent feature of the work of the Horticultural Section of the Station has been the testing of new varieties of fruits. Of the small fruits grown the strawberry has received a due share of attention. Five years ago a report was made (Bulletin 29) covering the varieties tested up to that time. Since then many varieties have been added to the collection. Some of these possessed merit, others were of no value. It is the purpose of the present paper to bring together the notes of the last five years, and record the estimates of value placed upon the different varieties under trial. It should be understood, however, that it is not the intention to recommend varieties for general planting. Observations on a particular variety continued through successive seasons enables us to rate with accuracy its value for this locality, and for the conditions under which it is grown, but we fully appreciate the fact that under different conditions of soil and surroundings its behavior may be quite different. Our best varieties may prove unprofitable in other localities, and some that are of no value here may take rank among the best when grown under different conditions.

Varieties of strawberries as well as of other fruits are largely local in character, and the best for a particular locality must be determined by trial in that locality.

Cultural directions for strawberries were given in Bulletin 29, but as the edition is exhausted and as inquiries on various cultural points are frequently received, it is thought best to again touch briefly upon the more important features of strawberry management.

## SOIL.

The strawberry can be made to grow on a great variety of soils, but it is easier to manage and reaches a better development on light loams than on heavy clays. A soil improperly drained, where water may stand for long periods, is entirely unsuited to this as well as to other fruits, and a very heavy clay is to be avoided if possible. A sandy loam of good fertility will produce earlier fruits than a heavy soil, it is easier to work, can be worked sooner after rains, and is in general more satisfactory. In many places along our streams there are broad stretches of bottom lands, sandy in texture and rich in humus, which, if well drained, are admirably adapted to strawberries.

It is best with any soil that it be cropped for one or two seasons before planting with strawberries, and preferably with crops that demand clean culture. It is of the first importance that the

land be free from weeds and in loose, mellow condition. It is not good practice to plant on freshly turned sod; such land should be used one season for some hoed crop, which will leave it in good condition for strawberries.

For most soils deep plowing is to be recommended. There is an advantage in inducing the plants to root deeply. The deeply loosened soil holds more water, and the plants are less liable to injury during scarcity of water.

#### LOCATION.

The location for strawberries should be chosen with particular reference to irrigation. Land lying nearly level is to be preferred, but gentle slopes can be utilized by planting on contour lines, or in such manner that the furrows for irrigating have only sufficient fall to move the water slowly without washing the soil.

Great care should be taken to have an even surface. High points must be lowered and all depressions filled, so that the furrows will nowhere overflow and flood the rows. This can be best accomplished by the use of a simple box scraper made of plank. Generally it is a good plan to plow deeply in the fall. If the soil is heavy and inclined to be lumpy it may be best to harrow at once after plowing, but with lighter soils this is not necessary. In the spring plow again and harrow until the surface is finely pulverized.

#### FERTILIZERS.

Colorado soils are yet new, they have been cropped for only a few years, and the question of fertilizers has not yet demanded much attention.

Locally their need is being felt, and no doubt the time will come when the problem of the maintenance of soil fertility will be as important here as it is now in the older agricultural districts. The intelligent application of fertilizers calls for inquiry into all the conditions surrounding, not only the locality, but the particular piece of soil to which the application is to be made. It is essential to know something of the physical condition. Is it heavy clay, or light sand? Is it loam or gravel? Is it level or sloping? Is the substratum rock or impervious clay, or is it porous gravel? Is the soil deep or shallow? Well drained or inclined to hold the applied water? Knowledge on these points is gained by observation and examination, and they are all important, because they have a direct bearing upon the kind and quantity of fertilizer, and upon the time and manner of its application. As supplementary to a knowledge of the physical condition of the soil, it would be well to know something of its composition as shown by chemical analysis. While I do not believe chemical analysis can be taken as an index of the producing power of any particular soil, it is valuable in connection



with a careful study of physical characters, in leading to the intelligent application of needed elements. Chemical values are potential, and while an analysis may accurately give the percentages of the various elements present, it can not tell with exactness what quantity of each essential element is in condition for immediate use as plant food. It is hardly possible to analyze the complicated processes that are taking place in the soil, converting complex inactive compounds into simpler forms ready for use in building up plant tissue. These processes are constantly in operation; they are less obvious and less known than many phenomena that are given prominence, but they are none the less important factors bearing upon the productiveness of soils.

An examination of several analyses of Colorado soils shows that they are rich in all of those elements classed among the inexhaustible soil ingredients, and that they also contain good percentages of the exhaustible elements which are so necessary to plant growth—nitrogen, phosphoric acid, and potash. It may be that much of the wealth of plant food shown by these analyses is not in an immediately available condition. If this be the case, what is the remedy? I may answer that the remedy may be sought in thorough cultivation and in an increase of humus by the addition of stable manure or by plowing under a soiling crop. Increase in the percentage of humus is important not only for its direct value as plant food, but for its influence on the physical condition of the soil, and for its action on other soil compounds. It makes clay soils less compact and increases the compactness of sandy soils; it increases the capillarity of the soil, thus bringing up to the roots food-laden water from below; it acts as a sponge to hold water in the soil, and it is a storehouse of nitrogen.

The strawberry is a gross feeder and to reach perfection demands a rich soil. I believe any soil intended for this plant will be benefited by a liberal application of stable manure, preferably that which has been rotted by composting. Our practice has been to apply a heavy dressing in the fall. This is plowed under and the surface harrowed down. Then water is applied until the ground is thoroughly soaked. In the spring we plow again and thoroughly pulverize the surface. The soil is then loose and moist at time of planting.

The principal objection to the use of fresh stable manure is that it is likely to carry with it many seeds of troublesome weeds. These seeds germinate or are in various ways killed during composting; then, too, the rotted manure is more readily incorporated with the soil and is more quickly available to the plants.

#### TIME TO PLANT.

In our practice at the Station we have had the best success from spring planting, and believe that in general it will be found

best for Colorado conditions. In regions where the rainfall is greater and where cloudless days are less common, planting in August is practiced successfully by many, but the practice is by no means universal, and most growers who plant large areas prefer to plant in the spring.

Here there is often trouble in obtaining the desired number of well-rooted young plants early enough so that when transplanted they may become well established before the end of the growing season. The prevailing bright suns during August are trying to newly set plants, they are liable to wilt and be severely checked, even when care is used to apply water frequently. Stronger plants are obtainable in the spring, the ground is then moist and the air cool, they are checked but little and make a strong growth from the beginning.

If potted plants are used, the objection to August planting has not the same force, but the expense of potting is such that the practice is not to be commended, except possibly in a small way for the home garden.

#### METHODS OF PLANTING.

Two systems of planting strawberries are in use. The hill system, and the matted row system. In hill culture the rows may be two and one half or three feet apart, with plants twelve inches in the rows. No runners are allowed to form, the plants are kept distinct and are encouraged to make the strongest growth possible. The fruits produced are large, but the labor involved is considerable and the system is only suitable for small areas. The matted row system is in almost universal use for commercial plantations because the labor is less and the quantity of fruit greater. The plants are set from eighteen to twenty four inches apart in rows three and one half or four feet apart. To enable the plants to become well rooted, it is best to remove all runners until about the first of July, after which the runners may be allowed to root until a space eighteen inches wide is filled. The ideal matted row should have a width of eighteen inches with the plants distributed at about equal distances, five or six inches apart.

Some varieties produce runners so freely that it may be necessary to thin them somewhat to obtain the best results.

In transplanting, care should be taken that the roots do not become dry. It is a good plan to carry the plants in some vessel containing water and to distribute only as fast as they can be planted. In planting, a spade or dibble may be used. The roots should be spread out fan shaped and care taken to plant at the right depth. If planted too deep the crowns are liable to rot, and if not deep enough the roots will dry out, either being fatal to the plant. The earth should be well firmed about the roots and the surface left level.



## IRRIGATION.

An ample supply of water is essential to success with Strawberries. The plants need it in quantity throughout the season and particularly while maturing fruit. No garden plants more quickly suffer from lack of water, and none respond more readily when it is properly applied. It is our practice to make a shallow furrow close to each row of plants as soon as they are planted and run water at once, even though the soil be moist. It settles the earth about the roots, is an insurance against possible dryness, and gives the plants a vigorous start.

It may happen after an exceptionally open and dry winter that the soil in spring is very dry. We may then proceed in one of two ways; either irrigate first, and then, as soon as the ground can be worked, plow and prepare for planting, or the land may be prepared first and furrows made in which water can be run as the plants are being set. Do not try to set the plants in the furrow, in wet soil, but plant on the borders of the furrow and so plan that water may soon after reach them. The first plan is the best, but it sometimes happens that the ditches are not supplied with water early enough. In that case the ground must be made ready and the planting delayed until water is available.

Care should be taken in running water that it be confined to the furrows and not allowed to flood the rows. It is better to run small streams for long periods than to try to hasten matters by running too much water. To insure an even, constant flow, we make a lateral across the ends of the rows and supply the furrow for each row through a short piece of one inch pipe which is imbedded in the bank of the lateral. This is safer and easier to manage than breaking the bank of the lateral for each furrow, especially in soils that are inclined to wash.

As to frequency of irrigation, no definite rule can be given; it must be determined for each particular piece of ground. Some soils may require twice as many applications as others. Study the condition of the soil and the appearance of the plants, and govern the water supply by the indications there found. A thorough irrigation late in the fall, just before the ground freezes, is an excellent protection against a possible dry winter.

## TILLAGE.

Thorough cultivation during the first season can not be too strongly urged. It conserves moisture, promotes the growth of plants, keeps the weeds down and is in every way beneficial. The after success of the plantation depends much upon the care given during the first months after planting. Cultivation should be continued until October, but after the runners commence forming new plants the space cultivated must be narrowed and the hoe used

among the plants. Train the runners within the limits of the matted row, and when enough plants are formed cut those that encroach upon the space between rows.

There are differences of opinion regarding spring cultivation of an established bed. Some allow the mulch to remain, and hold that it is best not to disturb the ground until after fruiting. Others remove the mulch and cultivate the spaces until fruit begins to set. We find it best to remove the mulch, because it interferes with furrowing for irrigation. The spaces are cultivated after each irrigation, until near the fruiting season, then furrows are made so that water can be applied as needed, and the bed is not further disturbed until after the fruit is picked.

#### MULCHING.

Mulching is regarded as an essential to success. It protects the plants from the ill effects of freezing and thawing consequent to the extreme daily range of temperature common during February and March, and it retards blooming, thus diminishing the danger from spring frosts. A light cover answers every purpose. Heavy mulching is unnecessary, and if too heavy may injure the plants. Hay, straw, coarse manure, leaves, and cornstalks have all been used as mulches. Marsh or swamp hay, if free from weeds, makes an admirable mulch, but often is not obtainable. Wheat straw is better than oat straw, because usually threshed cleaner, but with either kind it is safer to use old rather than new. If the bed to be mulched is exposed to strong winds, it will be necessary to use brush or poles to prevent the straw blowing from the plants. Coarse manure is usually objectionable as a mulch, because of the weed seeds it is likely to contain.

#### SELECTION OF VARIETIES. POLLINATION.

Varieties of strawberries are many, and choice of kinds should be made with reference to the proposed disposition of the fruit. If for home use or home market, high flavor in connection with size and productiveness would govern the choice, but if for shipment to distant markets, firmness and long keeping would be of first importance, and must be given preference over other good qualities. No variety has all the desirable qualities equally developed, that is, the ideal, all-purpose berry has not yet been produced, and the best we can do is to choose the nearest approach to an ideal for our specific purpose.

Choice can not be made from reports upon a particular variety for some other locality, but must rest upon actual trial in your own locality, because, as we have already remarked, the same variety may behave very differently under unlike surroundings. For commercial growing it is best to confine the attention to few varieties, and be certain before planting largely that these varieties



are adapted to your purpose and conditions. A succession to prolong the season may be desirable, but generally it will be found that the varieties intermediate in time of ripening prove most profitable. It is well enough to try novelties and new introductions in a small way, but never invest largely until their merits for your locality have been tested.

Choice must also be governed by blossom characters. Varieties are of two classes; those having perfect flowers, or in other words bearing both stamens and pistils, and those having pistillate flowers, or bearing pistils only. Some of our best varieties come under this latter class, and their ability to produce fruit depends entirely upon the proximity of other pollen producing varieties. Among the varieties bearing perfect flowers there is a wide difference as to pollen production; some have few and weak stamens and do not produce enough pollen to perfectly fertilize their own pistils; others have a normal complement of stamens with well filled anthers that have pollen to spare.

The strawberry is so commonly grown that it may seem unnecessary to dwell upon flower characters, but so many mistakes arising from inattention to these essentials have come under my immediate notice that the remarks upon the subject appear warranted.

If a pistillate variety has been decided upon, the question as to what proportion of the variety to be used as a pollenizer is necessary at once arises. On this point there is difference of opinion among growers. Some say four rows of the pistillate variety to one of the pollen producer, others would plant the two in equal quantity. I have found that two rows of the pollenizer alternated with four of the pistillate variety gave good results, but it may be as well to use them in equal proportions, particularly if both are desirable varieties.

A further point in reference to pollination may be touched upon here. Definite experiments upon apples, pears and plums have shown that some varieties are either wholly or in part self-sterile, that is, the pollen of a particular variety may be incapable of acting upon the pistils of that variety, or may act so slowly and imperfectly that the variety is unproductive. No definite experiments have been made upon strawberries, but observation leads to the suspicion that some varieties are, at least in some degree, self-sterile. If this be true, the obvious remedy is the same as recommended for the other fruits, namely, to mix varieties, not planting very large blocks of a single variety.

Fertilization in the strawberry is accomplished by insects, largely by bees, and if several varieties are near together the pollen is sure to be so distributed that the maximum of fruitfulness will result. Even if all varieties chosen for planting are strong pollen producers, we may infer from experiments upon other plants that

there would be advantage in planting in alternate narrow blocks in order to facilitate interchange of pollen, for it has been shown that some plants, although perfectly self-fertile, derived advantage from the use of foreign pollen.

A further point to be considered in choosing varieties to be planted together, is the time of blooming. To be of advantage to the pistillate variety, the pollen producer must bloom at the same time, and the same would be true if aiming at mutual advantage from cross-fertilization between perfect flowered varieties.

#### PICKING THE FRUIT.

If the berries are to be shipped some distance, it is important that they be picked at just the right degree of ripeness, not too green nor yet fully ripe. This can only be learned by experience.

The calyx with a short piece of stem should always be left attached to the fruit. Growers should watch that careless pickers pay attention to this point, as it is essential to the keeping quality. Berries detached from the calyx should go with the over ripe fruit and buttons, and these should never be mixed with good marketable berries, because they take from the value of the whole. Careful grading requires extra labor, but it is profitable. The grower who attends to it can establish such a reputation for his fruit that it will be always in demand, even at advanced prices. It is the common fruit that is always over-abundant in the markets. Choice fruit is, as a rule, scarce and seldom seen on the market in quantity equal to the demand.

After the fruit is all picked, the spaces between the rows should be cultivated and the rows cleared of all weeds by hoeing. Cultivation should be continued until October, and water should be applied as often as is necessary to promote vigorous growth. Good care will induce the formation of fruiting crowns, upon which the success of the next crop depends.

#### DURATION OF PLANTATIONS.

In our experience two years is as long as a bed can be maintained with profit. The first year of fruiting will give the largest fruit, the second the greatest quantity, then vigor diminishes; the rows are too crowded to admit the growth of new plants, weeds multiply and are hard to control; for these reasons it is best to plow up the bed immediately after the removal of the second crop. A new bed should be set each year and an old one plowed up. Following the plowing of an old bed, the land should be used for one season for some other crop, or it is possible to meet good results by sowing with some soiling crop as soon as plowed, this to be turned under in the fall.

Many eastern growers find greatest profit in the practice of taking but one crop. The plants are set in August, fruited the next



June and then turned under, but here in the west I believe it best to take two crops.

### DESCRIPTION OF VARIETIES.

**Annie Laura.**—bisexual. Originated with J. F. Beaver, Montgomery county, Ohio.

The plants are of good size and vigor, forming sufficient runners and young plants. The leafstalks are short and stout, the leaflets are medium to large, broad, rather thin, coarsely toothed, pale to dark green in color. The bloom is not abundant, the flowers are very large, the petals are often over five in number, the stamens are large and well formed.

The berries are large, short, blunt-conic to oblate, scarlet, with glossy surface, slow in coloring at tips, inferior in quality and yield.

First bloom 19th to 22d, and the last bloom about the 28th of May. First ripe berries about June 19th, and the last picking July 12th.

With us this is a poor variety.

**Aroma.**—bisexual. Originated with E. W. Cruse, Leavenworth, Kansas.

The variety is a healthy, vigorous grower, of medium habit, setting runners very freely. The leaflets are large, broad-oval, closely notched, dark green in color. The trusses are medium to long, stout, upright, with but few branches, and these produce but scant bloom. The flowers are large, the petals are often over six in number, and the stamens are well formed. The calyx is sometimes slightly irregular.

The berries are medium to large, broad-conic, uniform scarlet, with flesh usually of the same color but sometimes pink, quality fair, seeds prominent, yield and firmness medium.

First bloom May 19th, abundant bloom May 27th. First ripe berries June 20th, last picking July 7th.

The variety is not promising with us, but is reported to be very firm and of good quality at the Michigan Station.

**Atlantic.**—bisexual.

This variety is much like Seedling of Downing, a tall, vigorous grower, setting runners abundantly. The leafstalks are long and slender, the leaflets are medium to large, elliptic-oval. New foliage is pale, old foliage dark green, veins deeply impressed, trusses medium long, upright, rather slender, many-branched, bloom abundant, flowers medium size, petals usually five.

Berries large, short-conic, light red to scarlet in color but disposed to be green in spots, flesh white to light scarlet, seeds light, coloring in advance of the flesh and not set in deep pits, quality good, firm.

Blooms early. In 1896 it was in full bloom on May 12th and one half of the blossoms were killed by frost. Normally first bloom May 14th, abundant bloom May 23d. First ripe berry June 8–17th, last picking July 8th.

The variety is unproductive and unworthy of further trial.

**Barton.**—pistillate. Originated in Kentucky from seed of Longfellow.

Plants medium to large, setting young plants freely, foliage ample, leaflets broad, deeply and sharply notched, inclined to be light green in color, trusses medium long, fairly stout, sometimes decumbent, bloom fairly abundant, flowers medium to small, usually with five small, pointed sepals and five nearly round petals, stamens none, pistil light green.

Berries medium to large, broad-conic with an acute point, scarlet color but often pale at tips, seeds prominent, quality and yield good.

First bloom May 12–14th, abundant bloom May 20th. First ripe fruits June 14th, last picking July 17th.

The variety is quite subject to frost injury, but promises to be medium to good in value. At the Georgia Station it ranks good in productiveness, medium in quality and firmness and poor in vigor.

**Beder Wood.**—bisexual. Originated with Mr. Beder Wood, of Moline, Ill., 1887.

This is an early, vigorous variety, producing plants in abundance. The leafstalks are stout and often over six inches in length, the leaflets long-ovate and

dark green, trusses medium long, stocky, holding the blossoms as high as the foliage, bloom abundant, flowers medium size, regular, calyx rather small, with narrow, acute and often reflexed sepals. The stamens are numerous and well developed, pistils are pale in color.

Berries medium to large, uniform, nearly globular to short-oblong, frequently with a short neck, symmetrical, scarlet all over, seeds deeply set, flesh light colored, quality excellent, quite firm.

First bloom usually May 14-16th, abundant bloom May 19th. First ripe berry June 11th, full yield June 21st, last picking July 10th.

Although blooming early, it is but slightly injured by frost. We regard this as one of our most valuable varieties, especially desirable as a pollinizer for Warfield and other pistillates. It ranks well in value at the Kansas, Michigan, Montana and New York Stations, but is reported poor in quality, firmness and vigor at the Georgia Station.

**Belle of LaCrosse.**—bisexual. Originated with M. T. Crawford, Ohio.

This is a strong and vigorous grower, blooming freely but not setting many plants. It is well adapted to hill culture. The plants are large with broad crowns, leaflets medium to large, light to medium green, leafstalks medium to long, stout, trusses medium long, stout, upright, producing many blossoms and berries, flowers small to medium, petals usually five but often with an incomplete and undeveloped inner circle.

Berries medium size, conic, pointed, light scarlet shaded with crimson, flesh scarlet, seeds deeply set in irregular pits, quality good, acid, firm, yield abundant.

First bloom May 12-17th, abundant bloom May 24th. First ripe berry June 13-14th, first picking July 1st, good picking July 7th, last picking July 15th.

This variety is a late bloomer, but little injured by frost and is valuable with us. It is regarded valuable at the Michigan Station.

**Bessie.**—pistillate.

Plants medium to large, vigorous, light to dark green in color, foliage healthy, leafstalks erect, leaflets medium to large, long-ovate, trusses long, bloom scant, flowers medium size, petals five, stamens none.

Berries small to medium, conic, hull with difficulty, color deep red including flesh, firm.

First bloom the 17th, abundant bloom the 28th of May. First ripe fruit June 11th, first picking June 13th, last July 2d.

An excellent variety in growth and vigor but too unproductive with us to be of value. It is reported fairly vigorous, productive and of good quality and firmness at the Michigan Station.

**Beverly.**—bisexual. Originated with Benj. M. Smith, Beverly, Mass.

This is a second early sort, ripening with Warfield. It is a vigorous grower of medium habit, leaflets dark green in color, medium to large, broad, serrations deep, acute and usually overlapping, trusses long, upright, bloom abundant, flowers medium size, petals five, symmetrical, sometimes with a defective inner circle, stamens rather small, numerous and well developed, pistils pale green.

Berries medium size, globular to conic, seeds deeply set, surface rough, crimson, a little tardy in coloring at tips, quality good, acid, yield fair to good.

First bloom 12-18th, abundant bloom 24th of May. First ripe berries June 15-19th, first picking June 20th, best June 27th, last July 10th.

Variety of medium value with us and so reported from the Georgia and Michigan Stations.

**Bisel.**—pistillate.

Plants vigorous, medium in size, leaflets rather small, broad, dark green, trusses large, stout, bloom sufficient.

Berries small, conic with sharp apex, crimson, tip lighter, core slightly cartilaginous, yield only fair.

First bloom May 19th, abundant bloom May 24th. First ripe fruits June 19th, last picking July 2d.

So far the variety has done poorly with us. It is reported very favorably from the Montana Station but much less so from Georgia.



**Boynton.**—pistillate. Originated in N. Y., probably a cross between Crescent and Sharpless.

While ranking as a pistillate it is apparently capable of self fertilization. It is a vigorous variety, forms plants abundantly, leafstalks medium to long, slender, leaflets medium size, oblong, deeply and sharply toothed, medium to dark green, trusses medium to long, ascending, branches short, bloom abundant, flowers small to medium, petals usually five, round but sometimes pointed, not imbricate, stamens more developed than with most pistillate varieties but still rudimentary.

The berries are much of the Crescent type and character, medium size, short-conic, scarlet, flesh light, core somewhat cartilaginous, quality good, acid, flesh firm, yield good.

First bloom May 12–15th, full bloom May 20th. First ripe fruit June 10th, first picking June 13th, full picking June 26th, last picking July 13th.

The chief fault of this variety is that the berries become very small towards the close of the season. Although inclined to be soft, it is reported very favorably from the Kansas and the Minnesota Stations. At the latter Station it does best in hill culture.

**Brandywine.**—bisexual. Originated in Eastern Pennsylvania. Supposed to be a cross between Glendale and Cumberland.

The plant is of rather low habit, forming young plants abundantly. The leafstalks are short and stout, the leaflets large and broad, dark green in color, trusses medium length, stout, bloom production medium, anthers numerous, large and well formed.

Berries large, broad-conic, crimson, flesh ditto, slightly cartilaginous.

First bloom May 18–22d, abundant bloom May 29th. First ripe berry June 21st, last July 12th.

This is a variety of but medium value here. It is reported very favorably from the Georgia and the Michigan Stations, fairly well from Pennsylvania, but very poorly from Montana.

**Bubach** (No. 5).—pistillate. Originated with J. G. Bubach, Princeton, Ill.

The plants are vigorous, leafstalks medium to long, leaflets large, broad, coarsely and abundantly toothed, frequently with small interposed serrations, dark green, trusses not numerous, medium length, bloom scant, flowers fair size, often quite irregular.

Berries medium to large, conic, flattened at tips, colored well into the flesh but not uniformly on the surface, firm, seeds deeply set, quality fair, yield poor.

First bloom May 19th, abundant 28th. First ripe berry June 15th, last July 10th.

The variety is reported poorly from the Georgia Station, but quite favorably from the Kansas, Michigan, Montana and Pennsylvania Stations and from Sheridan and Lander in Wyoming.

**Capt. Jack.**—bisexual. Originated in Missouri with a Samuel Miller.

The variety is a vigorous grower, producing plants in great abundance. The leafstalks are short and stout, the leaflets are medium size, broad-oval, dark green, leathery, notches equal and similar, main axes of trusses stout and upright, branches long and spreading, bloom abundant and held above the foliage, flowers medium size, broadly expanded, petals usually five, round, flat, stamens numerous and well developed.

Berries light crimson, regular conic form, size medium, color uniform, flesh lighter, quality fair to good, a good shipper, quite productive.

First bloom May 12–17th, abundant bloom May 20th. First ripe berry June 6–10th, full picking June 20–27th, last picking July 10th.

This is a good early to mid-season variety, but the berries become too small later. It is an excellent pollenizer and is reported quite favorably from Kansas and Wyoming.

**Carrie.**—pistillate. A seedling of Haverland.

Plants large and vigorous, reproducing sufficiently. The leafstalks are stout, leaflets medium to large, dark green, leathery, trusses long, ascending, bloom abundant, flowers medium size, stamens large for a pistillate variety.

Berries resemble Haverland but are considerably larger, scarlet, firm, quality excellent.

First bloom May 19th, abundant bloom May 20-26th. First ripe fruits June 20-23d, last July 2d.

We consider this variety worthy of further trial. It is reported favorably from Michigan and Pennsylvania.

**Cornelia.**—bisexual.

This variety appears to be exactly like Glendale.

First bloom May 12th, full bloom May 25th. First ripe fruits June 17th, first picking June 22nd.

Reported favorably from Michigan and Pennsylvania.

**Crawford.**—bisexual. Originated with M. T. Crawford, Ohio.

The variety lacks vigor, producing but few plants. It has done too poorly to be worthy of description or further trial by us.

**Crescent.**—pistillate.

Plants of medium habit, very healthy and hardy, setting runners abundantly. The leafstalks are slender, leaflets long, frequently with two series of notches of very different size, color dark green, trusses medium length, bloom abundant, flowers small to medium, petals five, stamens rudimentary.

Berries medium size, conic with prolonged point, colored well, quality fair, acid, core somewhat cartilaginous, firmness and productiveness good.

First bloom May 12-16th, abundant bloom May 22d. First ripe berry June 7-15th, first picking June 15-20th, full picking June 27th, last July 10th.

The small size of the fruit, especially late in the season, is its chief fault. It is reported very vigorous and productive and of good quality and firmness from Georgia, Kansas, Michigan, Montana and Wyoming.

**Cumberland.**—bisexual.

Plants large, vigorous, setting young plants in sufficient numbers. The leafstalks are short and stout, the leaflets broad, roundish, bluntly toothed, medium dark green, trusses short to medium, stout, rays slender, bloom sufficient, flowers medium size, petals round, stamens well formed.

Berries large, short-conic to nearly globular, pale red, flesh light, hulls easily detached, appearance neat and smooth, quality excellent, rather soft, yield good.

First bloom May 15th, abundant bloom May 26th. First ripe fruits June 6-12th, first picking June 8-14th, full picking June 20-27th, last July 17th.

The variety is but slightly subject to frost injury. It is reported fair in Georgia, good in Kansas and very good at Sheridan, Wyoming.

**Edgar Queen.**—pistillate.

The plants are large and vigorous with abundant foliage, leafstalks are long and stout, leaflets medium to large, broad-ovate, medium shade green, teeth deep and sharp, trusses long, upright, stout, bloom very abundant, flowers medium size, petals six or more, frequently the inner petals forming rudimentary stamens.

Berries medium to large, globular, scarlet but not uniformly colored, quality fair to poor.

First bloom May 22d, abundant bloom May 29th. First ripe fruits June 18th, full picking June 27th, last July 12th.

The variety is a late bloomer but has the fault of light color, the fruit being green in spots. Many berries failed to develop. It is reported very favorably from Georgia and Michigan but only fairly so from Montana.

**Edwards' Favorite.**—bisexual. Probably a seedling of Jucunda.

Plants small to medium size, vigorous, producing runners freely. The leafstalks are short and very strong, leaflets ample, light glossy green, medium size, short, broad-ovate, serrations broad and rounded, trusses medium length and thickness, upright, bloom abundant, flowers medium to large, petals usually five but often more, frequently curled, pollen sufficient, calyx adherent.

Berries especially beautiful, large, uniform size, short-conic, smooth, bright scarlet, seeds light color, flesh firm.



First bloom May 10-16th, full bloom May 21st. First ripe berry June 15th, full picking June 20-27th, last July 17th.

The variety is an early bloomer. It is reported very favorably, except in vigor, from the Michigan Station.

**Enhance.**—bisexual.

Plants medium to large, vigorous, medium to light green, leafstalks long slender, erect, leaflets medium size, oval, teeth long and sharp, trusses short to medium, bloom abundant, flowers large, petals usually more than five, irregularly arranged, stamens well formed.

Berries medium size, crimson, tips slow in coloring, badly ribbed and irregular, sour. firm.

First bloom May 10-15th, full bloom May 12-23d. First ripe berries June 10-15th, first picking June 15-20th, full picking June 27th, last July 17th.

The variety is better for hill culture than for growing in matted rows. It is of low value with us, although it is a fairly good fertilizer for Bubach. It is reported very favorably from Georgia and Michigan and fairly so from Montana.

**Eureka.**—pistillate. Originated with Geo. Townsend, Soneham, Ohio, 1881.

Plants small to medium, producing sufficient young plants, leafstalks long and fairly strong, leaflets medium size, broad to long-ovate, deeply, sharply and irregularly notched and medium to dark green, trusses irregular in length, usually long and but little branched, mostly prostrate when loaded with fruit, bloom abundant, flowers small to medium, petals five to six, usually more, stamens undeveloped.

Berries large, scarlet to crimson, pink flesh, conic, frequently irregular in form and slow in coloring at tips, quality good, acid, firm, yield fair to good.

First bloom May 18-20th, full bloom May 26th. First ripe berry June 13-17th, full crop June 27th to July 6th, last picking July 17th.

The variety is late in blooming and ripening. It is of medium value with us. In Southern California it ranks low in bearing and in growth of vine.

**Gandy.**—bisexual.

Plants large and vigorous, do not run freely, best adapted to hill culture. Leafstalks very stout, leaflets large, long-ovate, coarsely toothed, medium to dark green, trusses long and stout, bloom abundant, flowers large, petals often more than five and frequently folded and irregular in appearance, stamens well developed, calyx large and reflexed.

Berries large, irregular, short-conic, frequently with a short neck, color bright scarlet, sometimes slow in coloring at tips, flesh light colored, seeds prominent, quality fair to good, firm.

First bloom May 17th, abundant bloom May 26th. First ripe berry June 18-21st, full picking June 26th to July 7th, last July 15th.

The variety is late in blooming and ripening and is of but moderate value. It is reported most unfavorably from Georgia, moderately favorably from Kansas, and very favorably from Michigan, Montana, New York, Pennsylvania and Sheridan, Wyoming.

**Glendale.**—bisexual.

Variety of tall habit, light green color, vigorous, produces sufficient young plants, leafstalks long, carrying the leaves frequently eight to twelve inches high, leaflets elliptical or oblong, finely serrate, trusses very long, bloom abundant, flowers medium to large, petals usually five but occasionally numerous, stamens fairly numerous and well developed, the first flower of each truss usually more or less compound.

First bloom May 19th, abundant bloom May 27th. First ripe fruit June 20-25th, full picking June 20th to July 6th, last July 17th.

The variety is like Seedling of Downing. It is of but little value here. The Kansas Station reports it very unproductive.

**Greenville.**—pistillate.

Plants large, dark green, vigorous, forming full matted row, leafstalks tall, leaflets large, broad, dark green, often streaked with light, sometimes curled slightly, coarsely notched, trusses medium long, stout, bloom sufficient, flowers small to medium, petals five to six, stamens none.

Berries medium to large, broad-conic, symmetrical, crimson, flesh colored, quality, firmness and yield good.

First bloom May 16th, abundant bloom May 22d. First ripe berry June 11-13th, first picking June 13-15th, full picking June 20-27th, last July 17th.

This is one of our best medium to late varieties. It is reported unfavorably from Georgia, Montana and Southern California Stations, but quite favorably from New York and Michigan.

**Gold.**—pistillate. Originated with P. M. Angar & Sons, Conn., 1880.

Plants medium size, pale yellowish color, lacking in vigor. Leafstalks medium length, somewhat drooping, leaflets medium size, broad-oval, trusses short, stout, bloom sufficient, flowers small, petals usually five with occasionally a partial inner circle.

Berries medium to large, short-conic, scarlet, flesh ditto, quality fair to good yield poor.

First bloom May 12th, full bloom May 22d. First ripe berry June 16th, first picking June 17th.

The variety is not a success under our conditions. It is reported quite unfavorably from Georgia and Sheridan, Wyoming.

**Gov. Hoard.**—bisexual. Originated in Wisconsin, a seedling of Sharpless.

The plants are large and quite reproductive. The leafstalks are long and stout, leaflets large, broad-ovate, medium green, trusses medium length, stout, bloom abundant, flowers large, petals usually five, stamens well formed.

Berries medium size, short-conic with neck, red all over, flesh colored well in, only fair in quality, firmness and yield.

First bloom May 12th, first picking June 17th.

Subject to frost injury, of no value on our grounds. Reported quite favorably from the Michigan Station.

**Gypsy.**—pistillate.

Plants of low habit, forming a thickly matted row. Leafstalks short and stout, leaflets broad, coarsely toothed, dark green in color, trusses short to medium, bloom sufficient, flowers small to medium, petals usually five, stamens none.

Berries medium size, short, round-conic, very symmetrical, uniform deep crimson color, flesh ditto, quality excellent, firm, yield medium.

First bloom May 16-18th, abundant May 21st, full bloom May 25th. First ripe berry June 5-14th, first picking June 11-15th, full picking June 20-27th, last July 12th.

We consider this an excellent variety and worthy of further trial. It is reported very favorably from Michigan, but at the Kansas Station is said to be a complete failure.

**Haverland.**—pistillate.

Plants of medium size, healthy and fairly vigorous although somewhat subject to leaf-curl. Forms a poor stand in matted row. Leafstalks are medium long, leaflets medium to large, rather broad, sharp toothed, medium shade green, trusses short to medium, more or less prostrate with twelve to sixteen blooms per truss, flowers small, parts arranged in plan of five, stamens none.

Berries very long with a neck, light scarlet, flesh ditto, quality very good, yield good.

The trusses are not strong enough to support the fruit. The calyx is somewhat reflexed.

First bloom May 8th, abundant bloom May 18th, full bloom May 21st. First ripe berries June 5th, first picking 8-10th, full picking 27th, last picking July 10th.

Although the blossoms and leaves are somewhat subject to frost injury we regard this as one of our best early varieties. It is reported unfavorably from Georgia though quite productive, fairly well from Kansas and Montana, and quite favorably from Michigan, New York and Sheridan, Wyoming.

**Hersey.**—bisexual. Originated with Samuel Hersey, Hingham, Mass.

Plants are of large and vigorous habit, reproducing abundantly. The leaf-



stalks are short and stout, the leaflets large, elliptical, teeth short and sharp, trusses long, bloom sufficient, anthers numerous but often poorly developed.

Berries large, long-conic with neck, color good, yield poor.

First bloom May 17-19th, abundant bloom May 28th. First ripe berry June 20th, best yield June 28th, last July 12th.

The variety is unworthy of further trial here. It is reported unproductive at the New York Station.

**Ironclad.**—bisexual.

Plants are of low habit, vigorous, reproducing fairly well. The leafstalks are short and stout, leaflets oval or broad-ovate, glossy dark green color, trusses medium length, stout, bloom abundant, flowers small to medium, petals five, stamens numerous and well developed.

Berries small to medium, conic with tips, color dark red, flesh ditto, quality good, firm, yield low.

First bloom May 13th, abundant bloom May 19th. First ripe berry June 13th, first picking 17th, full picking June 20-27th, last July 12th.

The variety will be discarded as unworthy.

**Ivanhoe.**—bisexual. Originated in Southern Ohio with Geo. W. Trowbridge, of Hamilton county.

Plants thrifty, foliage ample, leathery, dark green, blossoms medium size.

Berries large, conic, symmetrical, colored well, quality excellent but with a slight core.

First bloom May 21st, abundant bloom May 25th. First ripe berry June 20th.

This is a promising variety here. It is reported favorably from the Montana Station.

**Jay Gould.**—pistillate. Originated in Eastern Ohio, 1887.

The plants are of medium size and color, trusses medium long, bloom scant, flowers medium to large, showy, petals five to eight in a single circle.

Berries small, round-conic, crimson, flesh lighter, much like Gypsy in form, color and flavor, but smaller.

First bloom May 16th, abundant bloom May 24th. First ripe berry June 14th, last picking July 12th.

Variety undesirable here. Reported very favorably from the Michigan Station but unfavorably from the Montana Station.

**Jessie.**—bisexual—pistillate. Originated with Jas. W. Loudon, Janesville, Wis.

Plants very large and vigorous, producing young plants freely. Leafstalks long, leaflets very long, teeth large and irregular, medium green, trusses long and stout, bloom abundant. We have two strains of the variety. The flowers are large in the perfect-blossomed strain and small in the pistillate. Both strains are very productive of large berries, the earliest of which are often flattened and slow in coloring at tips.

Berries light scarlet, flesh lighter, quality good, calyx large, seeds prominent, quite firm.

First bloom 12-14th, abundant bloom May 23-24th. First ripe berry June 10-12th, last picking July 17th.

The development of the pistillate strain is slightly in advance of the staminate. The chief fault of the variety is the uneven ripening of the first fruits. At the Southern California Station it ranks low in production and growth of vine, at the Kansas Station very low in production, at the Georgia Station it is regarded as a good variety for amateur culture only, and in Wyoming it is not very successful, but is reported very favorably from the Michigan Station.

**Jucunda.**—bisexual.

Plants large, medium green, leaflets large and long, trusses long, bloom abundant, flowers large, petals usually five but frequently numerous in a single circle, stamens well developed.

Berries large, conic, frequently ribbed and irregular, quality fair, acid, yield medium.

First bloom May 12, full bloom May 22d. First ripe berry June 12th, first picking June 13th, last July 15th.

The variety was not a success here.

**Jucunda Improved.**—bisexual. Originated with A. B. Gerbert, of Eastern Pennsylvania. Probably a seedling of Jucunda.

The variety forms a thick mat of rather small plants, leaflets broad, medium green, bloom production fair, flowers large, petals usually six to seven but sometimes more, stamens well developed.

Berries a little broader than Jucunda, very large, crimson, surface smooth, short-conic, symmetrical, flesh pink, quality good, firm, yield low.

First bloom May 19th, abundant bloom May 29th. First ripe berry June 18–20th, full picking June 27th, last picking July 17th.

The variety rusts badly and is of little value here. It is reported very unfavorably from Georgia but quite favorably from Wyoming.

**Jumbo.**—bisexual.

A variety of the Sharpless type. Plants medium to large, medium vigor, fairly productive, leafstalks stout, medium to long, leaflets, large and broad-oval, deeply and sharply toothed, medium green in color, trusses medium long and medium stout with spreading, ascending branches, bloom production medium, flowers medium to large, petals usually six to ten, all somewhat curled, stamens imbricate and well developed.

Berries large to very large, oblong or somewhat rectangular, disposed to be irregular in form, color bright scarlet but slow in coloring at the tips, flesh nearly the same color, core somewhat stringy, quality fair, firmness and production medium.

First bloom May 9–12th, full bloom May 20th. First ripe berry June 15–18th, first picking June 19–20th, full picking June 26th, last July 8th.

This is a variety of strictly medium value here.

**Lady Rusk.**—pistillate.

The plants are large, running freely and making a full matted row. The leafstalks are long and stout, leaflets medium to large, long-ovate, rather unevenly toothed, medium to dark green, trusses medium to long, moderately stout, bloom production moderate, flowers small to medium, petals normally five, usually with undeveloped inner circle of two or three, stamens quite well developed for a pistillate variety.

Berries medium size, short, surface uneven and often more or less ribbed, dark crimson, tips slow in ripening, flesh yellowish pink, core soft or cartilaginous, quality and yield fair.

First bloom May 14–18th, abundant bloom May 21–23d. First ripe berry June 11–17th, first picking June 17–20th, full picking June 27th, last picking July 10th.

The plants and fruit much resemble the Crescent, although the fruit is more irregular in shape. It is a variety of medium value here. It has done fairly well in Kansas and Wyoming.

**Lady Thompson.**—bisexual.

Plants of medium habit, setting runners freely, large, vigorous, dark green, bloom sufficient, flowers large, stamens well formed.

Berries fair size, symmetrical, conic, often gemmate or twined, quality fair, yield good.

First bloom May 22d, abundant bloom May 25th. First ripe berry June 19th, last picking July 2d.

The variety is only moderately promising. It has done fairly well at the Georgia Station, but is pronounced a failure in New York, Ohio and Southern California.

**Leader.**—bisexual. Originated in Reading, Mass.

Plants of medium habit and vigor, producing young plants in sufficient number. Leafstalks short, leaflets medium to large, medium green, nearly round, small serrations frequently occurring between the larger ones, trusses medium long, stout, bloom production medium, flowers large and showy, calyx



large, sepals and petals usually exceeding the normal number, stamens numerous and well developed, pistils ditto.

Berries large, broad-conic and symmetrical but quite small after the first few pickings, deep scarlet, flesh ditto, seeds prominent, crimson, firm, quality good, acid, yield good.

First bloom May 16, abundant bloom May 21st. First ripe berry June 11-16th, first picking June 15-20th, full picking June 27th, last July 10.

The berries much resemble Warfield in shape and color. The plants have not been thoroughly healthy with us and were somewhat injured by frost in 1896. Reported inferior in production and flavor in Southern California, but very favorably except in vigor at the Michigan Station.

**Lida.**—pistillate. Originated with Wm. Parry, N. J., from seed of Chester.

Plants large and vigorous, reproducing freely, leafstalks medium to long, stout, leaflets medium size, broad-ovate, dark green, trusses medium to long, bloom fairly abundant, flowers medium size, petals five, many stamens fairly developed.

Berries large, short-conic or globular with a smooth surface, uniform light scarlet, flesh paler, quality good to excellent, a little soft, yield good.

First bloom May 10-12th, full bloom May 21-28th. First ripe berry June 12th, first picking June 13th.

It is reported low in vigor and production from Kansas and but slightly better from the Michigan Station.

**Loudon.**—bisexual.

Plants large but rather low in habit, a good plant producer, leafstalks medium long, stout, sharply and unevenly toothed, light green, trusses medium to long, stout, bloom sufficient, flowers large, petals usually five but sometimes six or more, stamens well formed.

Berries large, broad-conic, nearly globular, crimson but sometimes not uniformly so, flesh pale, quality fair to good, firm, calyx large and conspicuous.

First bloom May 10th or earlier, abundant bloom May 12-19th. First ripe fruits June 13-17th, full picking June 20-26th, last July 8th.

Variety of medium value. Reported very unfavorably from Georgia.

**Louisa.**—bisexual. Originated with Nicholas Hallock, of New York. Introduced by W. A. Burpee, 1888.

Plants medium to large, reproducing but moderately. Leafstalks long, medium strong, leaflets large, coarsely and often unevenly toothed, new leaves thin and light green but darker with age, flowers medium size, petals usually five, many blossoms pistillate.

Berries very large, oblong, with neck, light scarlet, flesh nearly white, seeds deeply set, flavor excellent, a little soft.

First bloom May 19th, abundant bloom May 26th. First ripe berry June 10-15th, first picking June 15th, full picking June 20th to July 7th, last July 15th.

A very good variety. Reported low in vigor and productiveness at the Kansas Station.

**Lovett.**—bisexual. Originated in Kentucky in 1885. Believed to be a chance seedling of Crescent x Wilson.

Plants of medium habit, healthy but somewhat subject to leaf curl, quite reproductive, leafstalks medium long, stout, leaflets medium size, thin, broad-ovate, sharply and irregularly toothed, medium to dark green, trusses short, stout, bloom abundant, flowers medium to large, petals usually five but frequently six to eight, stamens medium and well developed, calyx large.

Berries medium size, conic to long-conic, crimson, quality good, acid, firm, yield medium.

First bloom May 15-17th, full bloom May 22d. First ripe berry June 10-14th, full picking June 20-27th, last pick July 7th.

A variety of medium value here. Reported very unfavorably from Georgia, but better from Michigan, Montana and Sheridan, Wyoming.

**Louella.**—bisexual.

Plants large and vigorous, reproducing abundantly. Leafstalks medium long, erect, stout, leaflets large, long-ovate, medium green, trusses long and strong, bloom abundant, carried high, flowers large, petals five to six, stamens well developed, pollen very abundant.

Berries large, irregular-conic with neck, dark red, tips frequently green, flesh highly colored, quality good, acid, yield medium.

First bloom May 17th, full bloom May 21–27th. First ripe berry June 11th–23d, first picking June 15th, full picking June 27th, last July 15th.

**Manchester.**—bisexual.

Plants of medium habit, dark green, leathery, very like if not identical with Cumberland. Leafstalks short and stout, leaflets large, broad to round, serrations short, blunt and irregular, trusses medium long, bloom fairly abundant, flowers medium to large, petals usually five, stamens well developed.

Berries large, broad-conic, symmetrical, surface smooth and even, light scarlet, flesh light, seeds prominent, quality very good, not firm, yield fairly good.

First bloom May 10th, full bloom May 25th. First ripe fruit June 11–14th, first picking June 20–27th, last picking July 15th.

The variety is reported very productive at the Kansas Station, but is reported quite unfavorably from Georgia and from Sheridan, Wyoming.

**Margaret.**—bisexual. Originated with Jno. F. Beaver, Dayton, O., about 1891, from seed of Crawford.

The variety is a vigorous grower of medium habit, reproducing fairly well. Leafstalks medium long, stout, leaflets broad, coarsely toothed, leathery, trusses medium long, stout, bloom abundant, flowers large, petals five to nine, a good pollenizer.

Berries large, broad-conic, light crimson on exposed surface, scarlet on shaded portions, flesh pink to white, quality good, firm, yield fair.

First bloom May 13th, abundant bloom May 22d. First ripe fruit June 13th, first picking June 20th, full picking June 27th, last July 12th.

A good variety, deserving of trial. It is reported to be a promising pistillate variety at the Pennsylvania Station.

**Marshall.**—bisexual. Originated in Mass., introduced to the public in 1893.

Variety medium to large, vigorous, fairly reproductive. Leafstalks medium long, stout, leaflets large, broad, irregularly toothed, medium to light green, spotted to some extent, trusses medium to long, stout, bloom scant, flowers large, petals five to seven, in one whorl, occasionally some in an inner circle.

Berries large, broad-conic, crimson, tips often greenish, quality good.

First bloom May 15th, full bloom May 22nd. First ripe berry June 13th, first picking June 30th, last July 12th.

This is a promising variety, but it probably requires extra culture. It is reported very favorably from the Georgia and Michigan Stations.

**Michels Early.**—bisexual.

The variety is a very vigorous grower, of medium habit, setting plants and bloom profusely. It is an excellent pollenizer.

**Mrs. Cleveland.**—pistillate.

Plants large and vigorous, reproducing abundantly, leafstalks stout, leaflets ample, broad, coarsely toothed, light green, trusses medium long, bloom sufficient, flowers medium size, petals usually five, stamens none.

Berries large, round-conic, surface even, light scarlet, flesh light, quality excellent, slight core, firmness medium, yield good.

First bloom May 13th, abundant May 23d. First ripe berry June 13–15th, first picking June 16th, full picking June 26th, last July 8th.

An excellent kitchen variety. It is reported fair at the Kansas and good at the Michigan Station.

**Monarch.**—bisexual.

The plants are large and vigorous, leafstalks medium to long, leaflets small to medium, ovate, deeply notched, light green, trusses medium to long, stout,



bloom abundant, flowers medium to large, petals five to eight, imbricate, inner ones frequently much like the stamens, stamens medium size, numerous.

Berries large, conic, pale scarlet, inner flesh white, soft, quality good, yield good.

First bloom early, full bloom 1896 May 12th, abundant bloom 1897 May 27th. First ripe berry June 8–16th, first picking June 11th, last July 17th.

While inclined to bloom early, the variety is quite late in bearing, producing its full crop the latter part of June. The berries do not ripen evenly. Reported poorly from Georgia.

**Ontario.**—bisexual. Introduced from Canada by R. Johnston, of New York, 1885.

The variety is not vigorous nor productive of plants. Leafstalks medium long, stout, leaflets medium to large, light green, few in number, texture thin, trusses short, stout, drooping, branches long, bloom scant, flowers large, petals usually numerous and much folded, stamens well formed, calyx large.

Berries medium to large, oblong-conic or broader, scarlet, flesh colored, quality good, yield medium.

First bloom May 11th, full bloom May 22d. First ripe berry June 12th, last picking July 8th.

The variety has not done well. The fruit and foliage are both subject to frost injury. Reported fairly well from Georgia, excellent from Michigan, but very unproductive from Kansas.

**Parker Earle.**—bisexual. Originated 1886 with J. Nimon from seed of Crescent x T. V. Munson's No. 3.

Plants of medium size and vigor, reproducing abundantly. Foliage abundant, leafstalks long, erect, leaflets frequently unevenly notched, medium green, trusses medium long, stout, many-branched, sometimes as many as twenty per truss, bloom abundant, flowers medium size, petals usually five well formed, stamens numerous and well developed.

Berries large, long-conic, neck long, tips truncate, seeds depressed, color uniform scarlet, flesh lighter, quality good, firm, yield excellent, calyx reflexed.

First bloom May 17th, full bloom May 22–24th. First ripe berry June 15–19th, first picking June 20th, full picking June 27th, last July 12th.

This is our very best commercial variety. It is reported favorably from Georgia and very favorably from Michigan, rather unfavorably from Montana and Wyoming and poorly from Southern California.

**Pearl.**—bisexual. Originated in New Jersey.

Plants of Crescent type but smaller, leafstalks medium long, leaflets small, long-ovate, medium green, but slightly injured by frost, trusses short, bloom abundant, flowers medium size, petals five, stamens well developed.

Berries large, conic, symmetrical crimson, flesh ditto, quality good, soft, yield good.

First bloom May 12th, full bloom May 22d. First ripe berry June 10th, first picking June 15th, last July 15th.

Although lying on the ground, these are among our handsomest and best berries. Reported to be lacking in vigor and yield in Georgia and Kansas.

**Phillips.**—bisexual. A seedling of Sharpless.

Vigorous until attacked by mildew and spot. Leafstalks medium to long, slender, foliage ample, medium to dark green, leaflets medium size, oval, trusses shorter than leafstalks, bloom scant, flowers very large, petals usually six to eight, pollen abundant for a number of flowers.

Berries large, conic, truncate, badly ribbed, unevenly crimson, quality poor.

First bloom May 19th, full bloom May 24th. First ripe berry June 20th, last June 26th.

Not a promising sort. Reported favorably from the Michigan Station and from Georgia, when grown with Parker Earle.

**Princess.**—pistillate. Originated in Minnesota.

A low, vigorous grower resembling Pearl, although somewhat earlier and the fruit more nearly globular. Plants small to medium, leafstalks short, leaflets

medium size, broad, medium to dark green, truss axes short to medium, bloom production fair, flowers small to medium, petals not imbricate.

Berries medium size, short-conic to globular, deep crimson, flesh light scarlet, seeds deeply set, quality and yield good.

First bloom May 10-14th, full bloom May 19-22d. First ripe berry June 6-11th, last picking July 8th.

A good early to medium variety. Reported from Georgia as a poor grower but a very heavy mid-season cropper, the best on the Station grounds. It is reported very favorably from Michigan but poorly from Montana.

**Princeton Chief.**—pistillate.

Variety of tall habit, vigorous, reproducing abundantly. Leaflets large, long, somewhat tapering toward apex, light green, trusses exceedingly long, somewhat overtopping the leaves, bloom very abundant, flowers large, petals five to nine, stamens considerably developed.

Berries large, dark crimson, form irregular, yield good.

First bloom May 19th, abundant May 24th. First ripe berry June 21st, last July 17th.

This is a very late, promising variety. Reported unfavorably from Montana, from Georgia as lacking in form and productiveness, but very favorably from the Michigan Station.

**Puritan.**—pistillate.

Plants after the Crescent type but taller and the leaflets more sharply toothed. It is a very healthy and vigorous variety, forming plants abundantly, leafstalks long and stout, leaflets medium to large, dark green, serrations small, trusses medium to long, bloom sufficient, flowers medium size, petals usually five, stamens none.

Berries medium size, conic, irregular, surface uneven, crimson, very acid, yield good.

First bloom May 16th, abundant bloom May 28th. First ripe berry June 16th, full picking June 26th, last July 8th.

A late variety, poor to medium in value.

**Rio.**—bisexual.

A variety of Crescent type. Plants low in habit, vigorous, reproducing freely, leafstalks short and slender, leaflets small, light to medium green, trusses short and upright, bloom sufficient, flowers medium size, petals usually five, stamens well formed.

Berries medium size, broad-conic with somewhat prolonged point, bright scarlet, flesh ditto, quality good, acid, core cartilaginous, yield fair.

First bloom May 16th, abundant bloom May 22d. First ripe berry June 13th, last picking July 2d.

The variety is not desirable under our conditions. Reported unproductive at the Georgia Station, but favorably from Michigan.

**Seedling of Downing.**—bisexual.

A very vigorous variety, setting runners and young plants abundantly. Plants large, leafstalks long, stout, leaflets large, long and narrow, uniformly notched, light green, truss axes long and upright, bloom abundant, flowers small, calyx especially small, bowl-shaped, stamens well formed but not numerous.

Berries medium size, long-conic, scarlet, flesh ditto, seeds deeply set, giving the surface a rasp-like appearance, the seeds on the exposed surface becoming red while the flesh is still white, quality good, not a good shipper, yield fair.

First bloom May 12th, abundant bloom May 20th. First ripe berry June 14-17th, full picking June 20-26th, last picking July 12th.

Unworthy of trial under our conditions.

**Shuster's Gem.**—pistillate. A cross of Crescent x Sharpless.

Variety large, thrifty, reproductive, leafstalks long, slender, leaflets large, oval, light green, trusses medium to long, upright, bloom fairly abundant, flowers medium size, petals none.

Berries medium size, conic, symmetrical, clear scarlet, flesh lighter, quality good, sweet, lacks firmness, yield good.



First bloom May 12th, full bloom May 20th. First ripe berry June 10th, first picking June 15th, full picking June 20-27th, last July 10th.

A promising variety, worthy of trial. Reported favorably from Georgia, Kansas, Pennsylvania and Wyoming, but unfavorably from Montana and Southern California.

**Splendid.**—bisexual.

A large and vigorous variety, producing a full matted row. Plants large, leafstalks medium to long, leaflets large, oval, pointed, dark green, trusses medium to long, bloom abundant, flowers medium size, petals five to six.

Berries large, short-conic, blunt, crimson, flesh pale pink, white toward centre, tardy in coloring at tip, quality good, core sometimes cartilaginous, yield good.

First bloom May 17th, abundant bloom May 23d. First ripe berry June 17th, first picking June 20th, full picking June 27th, last picking July 12th.

A promising variety. Reported favorably from Michigan and Montana.

**Stayman's No. 1.**—bisexual. Originated in Southern Ohio. A seedling of Warfield.

Plants of medium size and vigor, reproducing fairly well. Leafstalks short to medium, leaflets medium size and shape, deeply notched, dark green, truss axes long, usually declined, bloom abundant, flowers small with parts arranged in order of five, petals smooth, stamens none.

Berries medium size, sometimes with a short neck, calyx reflexed, fruit conic, frequently double or even triple, the individuals being united to the tips, scarlet, flesh pink, core frequently cartilaginous, quality fair to good, acid, yield fair.

First bloom May 13th, abundant bloom May 22d. First ripe berry June 12th, first picking June 15th, full picking June 20-26th, last picking July 15th.

A variety of very moderate value. Reported favorably from Montana and Sheridan, Wyoming, but from Georgia as being very unproductive.

**Summit.**—pistillate. Originated with M. Crawford, Ohio, as Crawford's No. 6.

Plants large, vigorous, reproducing abundantly, leafstalks medium long, stout, leaflets medium large, round or broad-ovate, medium shade green, bloom sufficient but many barren plants, stamens often well developed.

Berries large, uniform, short-conic, quality and yield good.

First bloom May 10-12th. First ripe berry June 5th, first picking June 13th.

A desirable berry for home use. From Kansas reported to be extremely unproductive.

**Tennessee Prolific.**—bisexual. Seedling of Crescent x Sharpless.

Plants of medium habit, vigorous, reproducing abundantly. Leafstalks slender, leaflets medium long, unequally serrated, trusses medium long, mostly declined, bloom abundant, flowers large, petals five to six, anthers usually well formed, but the flowers sometimes partially pistillate.

Berries small to medium, irregular, color crimson to scarlet, flesh colored, core sometimes cartilaginous.

First bloom May 17th, abundant bloom May 22d. First ripe fruits June 5th, last picking July 12th.

The value of the variety is rather uncertain. Reported rather favorably from Michigan, but as being of little value at the Montana Station.

**Thompson.**—bisexual.

Plants of medium size, vigorous, reproductive, leafstalks long and slender, leaflets small to medium, long, teeth sharp, medium to dark green, trusses short and stout, branches long, bloom abundant, flowers medium size, petals often over five, stamens well formed.

Berries large, uniform, conic, pointed, occasionally with neck, bright scarlet, seeds light colored and prominent, quality excellent, mild acid, firm, yield excellent.

First bloom May 9th, full bloom May 20th. First ripe berry June 5th, first picking June 15-20th, last picking July 8th.

This is our best early variety. With Haverland in season.

**Timbrell.**—pistillate. Originated with H. S. Timbrell, of New York.

The variety is large, coarse and vigorous, but it does not set young plants freely. Leafstalks long and strong, leaflets broad-ovate, foliage strong, medium green, trusses short and stout, bloom abundant on individual plants, flowers medium size, petals five, stamens usually none but often well formed.

Berries medium to large, short-conic to globular, deep crimson with paler spots, quality good to excellent, firm.

First bloom May 17th, abundant bloom May 24th. First ripe berry June 16th, first picking June 18th, full picking June 27th, last July 17th.

The variety has not succeeded well. It is reported fairly well from Michigan, but as being very unproductive in Montana and Georgia.

**Tippecanoe.**—bisexual. Originated from seed brought from France.

A variety of medium habit, producing plants abundantly, leafstalks medium long, stout, leaflets medium to large, broad-ovate with rounded teeth, color dark green, trusses medium long, bloom sufficient, flowers large, petals usually five to eight in a single series, stamens usually well formed but sometimes undeveloped.

Berries large, regular globular form, scarlet, sometimes a little slow in coloring at tips, flesh yellowish pink, calyx large, quality and yield good.

First bloom May 15th, abundant bloom May 24th. First ripe berry June 12-16th, first picking June 15-19th, full picking June 26th, last July 15th.

A mid-season variety. It is one of our best large berries.

**Van Deman.**—bisexual. Originated with a Mr. Bauer.

Plants medium size, dark, glossy green, sets young plants abundantly, leafstalks medium long, leaflets medium size, long-ovate, trusses short, stout, much branched, bloom abundant, flowers medium size, petals five, stamens numerous and well developed.

Berries medium size, conic, uniform deep red, flesh ditto, seeds prominent, quality good, yield poor.

First bloom May 12th. First ripe berry June 11th, first picking June 15th.

The variety is somewhat subject to frost injury. It is reported rather unproductive from Kansas, Michigan and Montana, but of excellent quality and firmness.

**Warfield.**—pistillate. Originated with B. C. Warfield in Southern Illinois, 1883. Probably a seedling of Crescent.

Plants medium size, vigorous and healthy, very reproductive, leafstalks long, slender, leaflets medium-oval but sometimes narrower, sharply toothed, medium to dark green, trusses medium long, stout, bloom abundant, flowers small, parts usually arranged in order of five, stamens rudimentary, pistils a peculiar yellow color.

Berries large, uniform, symmetrical, conic, with a sharp tip and sometimes a short neck, deep crimson, flesh ditto, quality good, acid, firm.

First bloom May 13th, abundant bloom May 19th. First ripe berry June 5-12th, first picking June 11th, full picking June 26th, last picking July 18th.

This is our best pistillate variety. It ranks next to Parker Earle as a commercial berry. Beder Wood is probably its best pollenizer.

The variety is not valuable at the Georgia Station, but it ranks high in the reports from Kansas, Michigan, Montana and Wyoming.

**Westlawn.**—bisexual.

Plants of tall habit, large and healthy, setting young plants abundantly. Leaflets large and broad, coarsely toothed, light green, trusses long, slender, upright, bloom sufficient, flowers medium size, petals frequently six, stamens none.

Berries medium to large, uniform, broad-conic, tip long, irregular and slow in coloring, color deep scarlet, flesh light, seeds deeply set, calyx large, parting easily from fruit, quality only fair, acid, firm, yield fair.

First bloom May 12th, abundant bloom May 22d. First ripe fruit June 12-14th, full picking June 26th, last picking July 8th.

A fair mid-season variety. Unworthy of trial.



**Wilson's Albany.**—bisexual.

Plants small to medium, reproducing poorly, leafstalks medium long, stout, leaflets large, broad-ovate, medium dark green, trusses medium long, stout, bloom sufficient, flowers medium size, stamens well developed.

Berries small to medium, conic, crimson, flesh ditto, quality fair, acid, yield fair to good.

First bloom May 12th, blossoms but slightly subject to frost injury.

An undesirable variety. Reported unproductive at the Montana Station.

**Woolverton.**—bisexual. Originated with Jno. Little, of Canada.

Variety a robust grower but not easily established on heavy soils. Leafstalks medium to long, stout, leaflets ample, deeply toothed, flexible, long-oval, medium green, trusses long, stout, upright, flowers large, petals six to seven, many flowers with some petals imperfectly formed, stamens normal, calyx conspicuous.

Berries large, conic, sometimes flat at tip, deep crimson all over and well to centre, seeds prominent, firm, yield and quality good.

First bloom May 16th, abundant bloom May 25th. First ripe berry June 8-12th, first picking June 15th, full picking June 20-24th, last July 5th.

A good variety in many places. Reported quite favorably from Michigan but as being quite unproductive from Georgia.

**Yale.**—bisexual. Originated as a chance seedling in New Haven, Conn.

Plant of Warfield type but more robust, large and vigorous, leafstalks long, stout, leaflets long, broad, coarsely notched, dark green, trusses long, stout, upright, much branched, bloom abundant, flowers small, petals imbricate, round, stamens usually well formed but sometimes quite rudimentary.

Berries large, conic with prolonged tip, scarlet, flesh ditto, seeds light colored, quality fair, soft, yield poor.

First bloom May 14th, abundant bloom May 22d. First ripe berry June 15th, full picking June 20-25th, last July 10th.

A mid-season variety of medium value. Reported from the Georgia Station as very unproductive.

TABLE.

ABBREVIATIONS.

| <i>Sex.</i>    | <i>Form.</i>    | <i>Size.</i> | <i>Color.</i> |
|----------------|-----------------|--------------|---------------|
| p, pistillate. | b, broad.       | s, small.    | l, light.     |
| b, bisexual.   | c, conic.       | m, medium.   | r, red.       |
|                | d, depressed.   | l, larg..    | s, scarlet.   |
|                | i, irregular.   |              |               |
|                | r, round.       |              |               |
|                | n, with a neck. |              |               |

| VARIETY.              | Sex. | Vigor (1-10). | Date first bloom. | Date first ripe fruits. | Date last picking. | Productive-<br>ness,<br>(scale 1-10). | Size. | Form. | Color. | Quality. | Firmness. |
|-----------------------|------|---------------|-------------------|-------------------------|--------------------|---------------------------------------|-------|-------|--------|----------|-----------|
| Annie Laura .....     | b    | 8             | May 19            | June 19                 | July 12            | 6                                     | l     | dc    | bc     | 6        | 7         |
| Aroma.....            | b    | 8.5           | " 19              | " 20                    | " 7                | 7                                     | m-l   | bc    | s      | 7        | 7         |
| Atlantic .....        | b    | 8.5           | " 14              | " 12                    | " 8                | 7                                     | m-l   | bc    | lr-s   | 8.5      | 6.5       |
| Barton .....          | p    | 8             | " 13              | " 14                    | " 17               | 9                                     | m     | bc    | s      | 8.5      | 9         |
| Beder Wood .....      | b    | 8             | " 14              | " 11                    | " 10               | 8.5                                   | m     | rdc   | s      | 8        | 8.5       |
| Belle of LaCrosse.... | b    | 8.5           | " 14              | " 13                    | " 15               | 9.5                                   | m     | c     | s-c    | 8        | 8.5       |
| Bessie .....          | p    | 8             | " 17              | " 11                    | " 2                | 4                                     | s-m   | c     | dr     | 7.5      | 9         |
| Beverly.....          | b    | 8             | " 12              | " 15                    | " 10               | 7.5                                   | m     | bdc   | c      | 8        | 7         |
| Bisel .....           | p    | 8             | " 19              | " 19                    | " 2                | .....                                 | s     | c     | c      | 7        | .....     |
| Boynton.....          | p-b  | 9             | " 13              | " 10                    | " 17               | 9                                     | m     | bc    | s      | 8        | 8.5       |
| Brandywine.....       | b    | 8             | " 20              | " 21                    | " 12               | . . .                                 | l     | bc    | dc     | .....    | .....     |
| Bubach No. 5 .....    | p    | 8             | " 19              | " 15                    | " 10               | 9.5                                   | m-l   | ic    | s      | 7        | 8         |
| Capt. Jack .....      | b    | 9.5           | " 14              | " 10                    | " 10               | 8                                     | m     | c     | c      | 8        | 9         |
| Carrie .....          | p    | 8             | " 19              | " 21                    | " 2                | 8.5                                   | m-l   | lc    | s      | 9.5      | 9         |
| Cornelia .....        | b    | 8             | " 12              | " 17                    | .....              | .....                                 | ..... | ..... | .....  | .....    | .....     |
| Crescent .....        | p    | 8             | " 13              | " 10                    | July 10            | 8                                     | m     | lc    | lc     | 8        | 8         |
| Cumberland .....      | b    | 8             | " 15              | " 12                    | " 17               | 8.5                                   | l     | bdc   | lr     | 9.5      | 7.5       |
| Cyclone .....         | b    | 9.5           | " 13              | " 13                    | " 10               | 8.5                                   | s     | lnc   | s      | 8        | 8.5       |
| Edgar Queen. ....     | p    | 10            | " 22              | " 18                    | " 12               | 8                                     | m-l   | bdc   | s-l    | 7        | .....     |
| Edward's Favorite.... | b    | 8             | " 12              | " 15                    | " 17               | 8.5                                   | m-l   | bc    | bs     | 9        | 9         |
| Enhance .....         | b    | 7.5           | " 12              | " 12                    | " 17               | 8                                     | m     | bic   | c      | 8        | 9         |
| Eureka .....          | p    | 7.5           | " 18              | " 14                    | " 17               | 8                                     | m-l   | ic    | s-c    | 8        | 9.4       |
| Gardy .....           | b    | 8.5           | " 17              | " 19                    | " 15               | 8                                     | l     | ibcn  | bs     | 8        | 9         |
| Glendale .....        | b    | 8.5           | " 19              | " 20                    | " 17               | 7                                     | m-l   | lc    | ls     | 7        | 7         |
| Greenville .....      | p    | 9             | " 16              | " 13                    | " 17               | 8                                     | m-l   | c     | c      | 8        | 8.5       |
| Gold .....            | p    | 7             | " 12              | " 16                    | " —                | 5                                     | m-l   | bc    | s      | 7.5      | 8         |
| Gov. Hoard.....       | b    | 9             | " 12              | " 14                    | " —                | 7                                     | m     | bcn   | r      | 7        | 7         |
| Gypsy .....           | p    | 8.5           | " 16              | " 8                     | " 12               | 8                                     | m     | bc    | dc     | 10       | 9.5       |
| Haverland .....       | p    | 8             | " 8               | " 5                     | " 10               | 9                                     | m.    | lcn   | ls     | 8 5      | 8.5       |
| Hersey .....          | b    | 9.5           | " 17              | " 20                    | " 12               | 6                                     | l     | lcn   | s      | 7.5      | 8         |
| Ironclad .....        | b    | 8.5           | " 13              | " 13                    | " 12               | 7                                     | s-m   | lc    | dr     | 8        | 8.5       |



TABLE—(Continued).

| VARIETY.               | Sex. | Vigor (1-10). | Date first bloom. | Date first ripe fruits. | Date last picking. | Productive-ness, (scale 1-10). | Size. | Form. | Color. | Quality. | Firmness. |
|------------------------|------|---------------|-------------------|-------------------------|--------------------|--------------------------------|-------|-------|--------|----------|-----------|
| Ivanhoe .....          | b    | 9             | May 21            | June 20                 | July 12            | 8                              | l     | c     | c      | 9.5      | 9         |
| Jay Gould .....        | p    | 8             | " 16              | " 14                    | " 12               | 7.5                            | s     | bdc   | dc     | 9.5      | 8.5       |
| Jessie .....           | b-p  | 10            | "12-14            | "10-12                  | " 17               | 8.5                            | l     | c-ic  | ls     | 9        | 9         |
| Jucunda .....          | b    | 8             | " 12              | " 12                    | " 15               | 7.5                            | l     | lc    | s      | 7.5      | 8         |
| Jucunda Improved ...   | b    | 8.5           | " 19              | " 19                    | " 17               | 7                              | l     | c     | c      | 8.5      | 8.5       |
| Jumbo .....            | b    | 8             | " 9               | " 15                    | " 8                | 8                              | l-vl  | ldic  | bs     | 7        | 7         |
| Lady Rusk .....        | p    | 10            | " 14              | " 13                    | " 10               | 7                              | m     | bic   | dc     | 7        | 7         |
| Lady Thompson .....    | b    | 9             | " 22              | " 19                    | " 2                | 9.5                            | m     | c-ic  | s-c    | 7.5      | 8         |
| Leader .....           | b    | 7             | " 16              | " 13                    | " 10               | 8                              | m-l   | bc    | ds     | 8        | 9         |
| Lida .....             | p-b  | 9             | " 11              | " 12                    | " —                | 8                              | l     | bc    | ls     | 9        | 7.5       |
| Loudon .....           | b    | 8.5           | " 10              | " 13                    | " 8                | 8                              | m-l   | bdc   | s-c    | 8        | 9         |
| Louisa .....           | b-p  | 8             | " 19              | " 12                    | " 15               | .....                          | vl    | lden  | ls     | 9.5      | 8         |
| Lovett.....            | b    | 8.5           | " 15              | " 11                    | " 7                | 8                              | m     | c-lc  | c      | 8.5      | 9         |
| Louella .....          | b    | 9.5           | " 17              | " 14                    | " 15               | 8                              | l     | icn   | dr     | 8.5      | 8.5       |
| Manchester.....        | b    | 8             | " 10              | " 12                    | " 15               | 8                              | l     | bdc   | ls     | 9.5      | 7.5       |
| Margaret .....         | b    | 3             | " 13              | " 13                    | " 12               | 7.5                            | l     | bc    | lc     | 8.5      | 9         |
| Mark .....             | b    | 9             | " 14              | " 20                    | " 15               | 8                              | m     | bc    | s-c    | 5        | 9         |
| Marshall .....         | b    | 8             | " 15              | " 13                    | " 12               | 8.5                            | l     | bc    | c      | 8        | 8         |
| Mrs. Cleveland .....   | p    | 9.5           | " 13              | " 13                    | " 8                | 8.5                            | l     | rc    | ls     | 9        | 8         |
| Monarch .....          | b    | 8.5           | " 8               | " 10                    | " 17               | 8.5                            | l     | c     | ls     | 8        | 7         |
| Ontario .....          | b    | 5             | " 11              | " 12                    | " 8                | 7                              | m-l   | ldc   | s      | 8.5      | 8         |
| Orange Co.....         | p    | 7             | " 13              | " 13                    | " 12               | 7                              | m     | brc   | ls     | 8.5      | 8         |
| Parker Earle .....     | b    | 9.5           | " 17              | " 16                    | " 12               | 10                             | m     | lcn   | ds     | 8        | 9         |
| Pearl .....            | b    | 8             | " 12              | " 10                    | " 15               | 8                              | l     | c     | c      | 9        | 8         |
| Phillips .....         | b    | 8             | " 19              | " 20                    | June 26            | 8                              | m     | lide. | lc-c   | 6        | 7         |
| Princess.....          | p    | 7.5           | " 12              | " 8                     | July 8             | 8.5                            | m     | rc    | dc     | 8.5      | 8         |
| Princeton Chief.....   | p    | 9.5           | " 19              | " 21                    | " 17               | 8.5                            | l     | ic    | dc     | 8.5      | 8.5       |
| Puritan .....          | p    | 10            | " 16              | " 16                    | " 8                | 8.5                            | m     | ic    | c      | 7        | 8         |
| Rio.....               | b    | 9             | " 16              | " 13                    | " 2                | 7                              | m     | lbc   | bs     | 8.5      | 7         |
| Seedling of Downing..  | b    | 9.5           | " 12              | " 14                    | " 10               | 7                              | m     | lc    | bs     | 8        | 7         |
| Shuster's Gem.....     | p    | 9.5           | " 12              | " 10                    | " 10               | 8                              | m-l   | c     | bs     | 8.5      | 8         |
| Splendid .....         | b    | 10            | " 17              | " 17                    | " 12               | 8.5                            | l     | bdc   | c      | 8        | 8         |
| Stayman's No. 1 .....  | p    | 8             | " 13              | " 12                    | " 15               | 7.5                            | m     | icn   | s      | 7.5      | 8         |
| Summit .....           | p    | 9             | " 11              | " 5                     | " —                | 8.5                            | l     | bc    | ls     | 8        | 7         |
| Tennessee Prolific.... | b    | 8.5           | " 17              | " 15                    | " 12               | .....                          | s-m   | ic    | c-s    | 8        | 8         |
| Thompson .....         | b    | 8.5           | " 9               | " 5                     | " 8                | 9.5                            | m     | c-cn  | bs     | 9.5      | 9.5       |
| Timbrell .....         | p    | 8             | " 17              | " 16                    | " 17               | 8                              | m-l   | bdr   | dc     | 9        | 9.5       |
| Tippecanoe .....       | b    | 8             | " 15              | " 14                    | " 15               | 8                              | vl    | rdc   | s      | 8        | 8         |
| VanDeman .....         | b    | 9             | " 12              | " 11                    | " —                | 7                              | m     | c     | dr     | 8        | 8.5       |
| Warfield.....          | p    | 9             | " 13              | " 8                     | " 15               | 10                             | m     | c     | c      | 8        | 9.5       |
| Westlawn .....         | b    | 8             | " 12              | " 12                    | " 8                | 8                              | m-l   | bc    | ds     | 7        | 8.5       |
| Wilson's Albany .....  | b    | 7.5           | " 12              | .....                   | .....              | 8                              | s-m   | c     | c      | 7        | 8         |
| Woolverton .....       | b    | 8             | " 16              | June 12                 | July 5             | 8                              | l     | c-ic  | dc     | 8        | 9         |
| Yale .....             | b    | 9.5           | " 14              | " 15                    | " 10               | 7                              | l     | lc    | s      | 7        | 7         |

## Supplementary List of Varieties.

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Since the publication of our last strawberry bulletin (No. 29, 1894), the following varieties, not found in the preceding list, have been introduced to the Station grounds. Of this number a few have failed to become established. The others will be reported upon as soon as sufficient trial has been given them:

Anna Kennedy,  
Bouncer,  
Clarence,  
Cyclone,  
Downing's Bride,  
Enormous,  
Gardner,  
Great Pacific,  
Hatfield,  
Hunn,  
Jersey Market,  
Leo,  
Manwell,  
Murray X Early,  
Ocean City,  
Pet,  
Pride of Cumberland,  
Seaford,  
Staples,  
Vories,  
William Belt,

Berlin,  
Brunette,  
Clark Early,  
Cobden Queen,  
Earliest,  
Erie,  
Giant,  
Gros Lombard,  
H. W. Beecher,  
Ideal,  
Klondyke,  
McKinley,  
Mary,  
Nick Ohmer,  
Oriole,  
Plow City,  
Ridgeway,  
Sharpless,  
Sunnyside,  
Wild's No. 8,  
Wilson,

Bismark,  
Champion of England,  
Clyde,  
Darling,  
Eleanor,  
Equinox,  
Glen Mary, .  
Halls,  
Howell,  
Improved Parker Earle,  
Laxton,  
Magoon,  
Michigan,  
Noble,  
Patrick,  
Premium,  
Ruby,  
Sparta,  
Tubbs,  
Wild's No. 35.



Bulletin 54.

May, 1900.

# The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

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## APIARY EXPERIMENTS.

—BY—

CLARENCE P. GILLETTE.

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PUBLISHED BY THE EXPERIMENT STATION,  
Fort Collins, Colorado.  
1900.

# The Agricultural Experiment Station,

FORT COLLINS, COLORADO.

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# APIARY EXPERIMENTS.

## FOUNDATION IN COMB BUILDING.

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By CLARENCE P. GILLETTE.

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Honey bees collect liquid sweets from all available sources, chiefly in the form of nectar from flowers, and when the product has been elaborated in the honey-stomach and afterwards stored in comb, we call it honey.

The material from which the comb is built is not collected as wax, but is formed within the body and secreted in the form of thin scales between the abdominal segments on the under side.

As the wax is elaborated within the body, the bee must be supplied with food out of which to form it and, according to experiments reported on another page, it requires about one pound of wax for every twenty-five pounds of honey stored in comb. The food required for the secretion of wax is, for the most part, honey; and as it requires several pounds of corn to produce one pound of beef or butter, so it doubtless requires several pounds of honey as food for worker bees to enable them to produce one pound of wax.

But the consumption of honey for wax production does not represent the total cost of the wax to the colony. The bees that secrete it are called off from the field force, so that the income of the colony is lessened. In a state of nature this wax production entails no heavy drain upon the colony, as the comb, once built, lasts for years; but where comb honey is being produced for the market, it becomes a matter of economic importance to know to what extent and in what form wax can best be furnished bees for their use in comb building.

So far as we know at present, there is but one general way to furnish the wax for this use, and that is in some form of artificial comb foundation. But there are many types of this foundation. Is it better to have the base or midrib only—the “no wall” foundation? or is it better to have the cell walls outlined for the bees? If the latter, should we have these walls short or long? In either case, is

it better to put most of the wax in the midrib or the cell walls? When it is determined how the wax is best proportioned between the midrib and cell walls, what weight of foundation is best?

The experiments here reported were undertaken for the purpose of casting some light upon these and related problems and, it is believed, with some good results. It is not to be expected that all these questions are fully settled in this paper.

#### DO BEES USE WAX FROM ARTIFICIAL FOUNDATIONS TO EXTEND THE CELL WALLS AND THE COMB MIDRIB?

The common belief that wax is so used was graphically proven by the following experiment:

A few sheets of thin foundation that was made black by the addition of lamp black to the melted wax were prepared for me by Mr. C. B. Elliott, of Denver. This foundation was used in sections which were placed in supers for comb honey. In some sections starters one inch wide were used, while in others were placed full sheets. The bees accepted this black foundation as readily as any and built comb upon it. A photograph of comb built upon this foundation is shown in Plate 1. At *a* is a section containing a starter one inch wide that the bees had worked but little. At *b* are two cross sections of comb built upon such a starter. The white cross-lines show where the lower edges of the starters came, and the dark color shows to what extent the foundation was used in extending the comb. At *c* is a section of drawn comb built upon a short starter as shown at *a*. The white line marks the lower margin of the foundation, and the dark color in the comb shows to what extent the foundation was used in building down the comb. At *d* is shown comb built on a large piece of the black foundation. The cell walls are deep black at the bottom and gradually fade until the top or outer end of the wall is reached, where the dark color hardly shows. This could only come about by the bees using other wax, probably directly from their bodies, which was mixed with the wax of the foundation.

These experiments prove so conclusively that bees do use wax from foundations to extend both cell walls and midrib, that we are now ready to ask:

#### IS THE WAX OF THE MIDRIB OF THE FOUNDATION USED IN COMB BUILDING, AND, IF SO, WILL IT BE CUT DOWN TO THE THINNESS OF THE MIDRIB IN NATURAL COMB?

To determine these points we shall have to compare the thickness of the artificial foundation with the thickness of the comb midrib built upon the foundation, and the latter with the midrib of comb built entirely by the bees.



*Table Showing the Weight, in Grains per Square Inch, of Different Kinds of Artificial Foundation, and of the Midribs of Comb Built upon Each.*

| Very Heavy Foundation        |                    | Medium Brood Foundation |                    | 1898 Deep-Cell Foundation* |                       |                    | Thin Super Foundation |                    | Extra Thin Foundation |                    | † 1899 Deep-Cell Foundation |                    | Midribs of Natural Worker Comb |
|------------------------------|--------------------|-------------------------|--------------------|----------------------------|-----------------------|--------------------|-----------------------|--------------------|-----------------------|--------------------|-----------------------------|--------------------|--------------------------------|
| Entire Foundation            | Midribs of Comb on | Entire Foundation       | Midribs of Comb on | Entire Foundation          | Midribs of Foundation | Midribs of Comb on | Entire Foundation     | Midribs of Comb on | Entire Foundation     | Midribs of Comb on | Entire Foundation           | Midribs of Comb on |                                |
| H. 12.                       | 10.10              | 8.80                    | 6.87               | 5.55                       | 2.55                  | 4.10               | 4.20                  | 3.70               | 3.64                  | 3.12               | 5.12                        | 3.74               | 3.20                           |
| L. 10.                       | 7.00               | 8.10                    | 3.50               | 5.38                       | 2.40                  | 3.00               | 4.00                  | 2.40               | 3.53                  | 2.75               | 4.44                        | 2.83               | 1.65                           |
| Ave. 11.                     | 8.00               | 8.40                    | 5.18               | 5.46                       | 2.50                  | 3.44               | 4.07                  | 3.00               | 3.60                  | 2.95               | 4.50                        | 3.22               | 2.10                           |
| Heavier Than Natural Midrib. | 5.90               | —                       | 3.08               | —                          | .40                   | 1.34               | —                     | .90                | —                     | .85                | —                           | 1.12               | —                              |

The accompanying table gives, in the upper line, the heaviest weights found ; in the second line the lightest weights ; and in the third line the average weights, computed from a good number of examples in each case. The excess in weight above that of the midrib of natural worker comb is given in the bottom line.

The differences in weight between these foundations and the midribs of comb built upon them do not represent the weight of the wax removed from the midrib of the foundation by the bees, as the foundation has short cell walls which are also thinned. These may be seen by looking at illustrations of sections of foundation in Plates 2 and 4. It will be seen by the table that none of the comb built on foundation has a midrib as light as that of the natural worker comb, though, in some cases, the midribs of comb on thin and extra thin super foundations and on the "1899" deep-cell foundation are but little heavier than those of natural comb.

It will also be noticed that, while the midrib of the "1898" deep-cell foundation itself was but little heavier than that of natural worker comb, the comb built upon this foundation had a midrib much heavier than that of the natural. The reason for this will be given directly. The table also shows that the heavier the midrib of the foundation, the heavier will be the midrib of the comb upon the foundation. This would be a general rule that might have exceptions.

\* This foundation was obtained for experiment in 1898, when it was comparatively a new product, so I have called it "1898" deep-cell foundation to distinguish it from the foundation mentioned below.

† Samples of this foundation were first received in 1899, and I have designated it the "1899" deep-cell foundation to distinguish it from the preceding.

The above table shows that the very heavy foundation gave a comb midrib weighing 5.90 grains more to the square inch than the midrib of natural comb. Medium brood foundation gave a midrib 3.08 grains heavier to the square inch, or almost two and one-half times the weight of natural midrib. The lightest midribs were obtained by the use of extra thin and thin super foundations, averaging but .85 to .90 grains to the square inch more than natural midrib.

The use of the "1898" deep-cell foundation manufactured by Mr. E. B. Weed gave rather surprising results. The midrib from the foundation, before it had been worked over by the bees, averaged but .40 grains to the square inch more than the natural midrib, while the midrib of comb built on this foundation weighed 1.34 grains more. The midrib of this foundation was not uniform in thickness, in some places being thinner and in others thicker than in natural comb, as shown in Plate 4, Fig. *d*. Where the midrib was thick there was little or no thinning by the bees, but where it was very thin they reinforced the weak places by "plastering" on a quantity of wax. These thickened places are plainly shown at *n*, Fig. *c*, and at *f* of the plate just mentioned; and at *b* of Plate 1, and account for the increased weight of the comb midrib. Fig. *f*, just mentioned, is from one of the worst samples I have seen. Natural midrib is shown at *e*.

The difference in weight between the heavier artificial foundations and the midribs of the comb built upon them is too great to result from the thinning of the short cell walls alone, and can only be accounted for on the supposition that the bees do remove wax from the midribs of these foundations. The examination under a microscope of any heavy foundation that the bees have just begun to work will show the marks of their mandibles in the wax. At first the wax is left very rough, as shown in Plate 1, Fig. *g*, considerably magnified. At *h* is shown the smooth bottoms of the finished cells on the same foundation, which was medium brood in both cases.

To be convinced that heavy foundations have their midribs thinned, but not thinned to correspond with the midribs of natural comb, the reader has only to look at the figures in Plate 2. At *a* is shown a section of heavy foundation, and at *b* and *g* are shown midribs of comb built on this foundation. The lower third of *b* is a midrib of natural comb built on the foundation. At *c* and the lower end of *d* are shown sections of the medium brood foundation, while the upper portion of *d* and all of *e* show to what extent the midrib of this foundation was thinned. Notice also in this connection, that the full thinning of both foundation and cell walls is accomplished while the walls are yet quite short.

The fact that foundations are thinned was also shown by actual



measurements. A large number of \*plaster casts of comb on different foundations and of the foundations themselves were made, and then cut in different directions as shown in Plates 2 and 5. This made it possible to cut the wax of the different cells so that the thickness could be measured. A large number of measurements were made and tabulated, but the variations are so great in thickness of both midribs and cell walls in all kinds of comb that I have thought it not worth while to include the table here, but will state the general results.

† The common range in thickness of the midrib in naturally built worker comb was found to be between .08 and .16 millimeters.‡ In drone comb the common range was between .12 and .20 millimeters. None of the midribs of comb built on artificial foundations averaged as thin as the natural midrib in worker comb. In some cases those from thin and extra thin super foundations, and the "1899" deep-cell foundation approximated it closely. Where the midrib of a foundation is not thicker than about .17 millimeters, the bees seem not to thin much if any, though they go over the surface with their mandibles and scrape it so that it loses its transparency.

It was also noticed that the midrib of any comb was thicker near its attachment, at the top, sides or bottom, than at some distance from these attachments. Illustrations of this may be seen in Plates 2 and 3. Fig. *c* of the latter plate shows a cut through the comb of a pound section made from side to side.

The heavier midrib and cell walls in drone comb are necessary to give it the same strength as worker comb, because the larger the cells the fewer the number, and the smaller the amount of wax required to build them to a given thickness.

Sections of natural worker comb are shown at *b*, *c*, and *e*, and the lower halves of *a* and *g* of Plate 3. Drone comb is shown in the lower part of *i* in Plate 2, and in *f* of Plate 3.

The midrib of comb built on "1898" deep-cell foundation was very irregular in thickness, for the reasons already given, and averaged about the same as drone comb. See Plate 4, Figs. *c* and *f*. Medium brood foundation also gave wide variations in the amount of thinning.

At Plate 2, *d* and *e*, are two of the best thinned samples I have seen, though little drawn. At *f*, Plate 5, is a sample of fully drawn comb on this foundation which has the midrib thinned but little.

At *f*, Plate 2, is shown a section of super foundation obtained from Mr. Elliott, of Denver, and at *h* is a section through comb on

\* I got this idea from Mr. E. R. Root, Editor of "Gleanings in Bee Culture."

† I have not found any samples of natural comb with as heavy cell walls as those shown on page 69 of "A, B, C of Bee Culture," Figs. 1 and 2.

‡ Reduce millimeters to inches by dividing by 25.

this foundation. The midrib averages about .17 millimeters in thickness, or fully as heavy as the midrib in drone comb. The upper half of *i* in this plate is also on this foundation, and the midrib is rather heavier than the midrib of the drone comb which the bees built, shown in the lower half of the figure.

At *j* of Plate 2 is shown a section of thin, and at *l* of the extra thin super foundations. The two differ chiefly in that the former has rather heavy cell walls, while the extra thin has almost no walls. At *k* is a section showing partially drawn comb on the thin super foundation, and at *g*, Plate 5, is a sample of fully drawn comb on the extra thin foundation. It will be noticed that the midribs of the comb samples built on these foundations are in most cases nearly, if not quite, as thick as in the foundations themselves. At *a* of Plate 3 is a section through comb, the upper two-fifths of which was built upon the thin super foundation and the lower three-fifths is natural. The midrib of the foundation seems not to have been thinned at all, and contrasts plainly with the midrib of the portion that was built entirely by the bees, and also with the midribs of figures *b* and *c* of the same plate, both of which represent natural comb.

At *g* of Plate 4 is shown a section of the beautiful "1899" deep-cell foundation, as I have termed it, that is manufactured by Mr. E. B. Weed. At *h* of the same plate is shown comb slightly worked on this foundation, and at *a* of Plate 5 is shown fully drawn comb on the same. Here again it will be noticed that the midrib is scarcely if at all thinned, and is as heavy as that of drone comb.

The evidence thus obtained by measuring the thickness of the midribs of foundations and of the comb built upon them bears out the results obtained by weighing, namely, that heavy foundations have their midribs thinned some, usually much, by the bees when they build comb upon them; but these are not thinned, in any case, to the lightness of natural worker comb. If the midrib is not thicker than .17 millimeters—.068 of an inch—the bees thin it little if any; if the midrib is much thinner than the normal, the bees are likely to thicken it by the addition of wax, making it much heavier than in natural comb.

#### DOES THE USE OF ARTIFICIAL FOUNDATIONS RESULT IN THICKER CELL WALLS IN THE COMB?

It is evident that a slight thickening of the cell walls increases the weight of the comb more than the same thickening of the midrib. \*Cheshire estimated that the area of the cell walls of worker comb one inch thick is fully ten times that of the midrib upon which they are built. If this be true (and the difference in area is

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\* "Bees and Bee-keeping," Vol. II., page 213.



greater when the comb is more than an inch thick), then the thickening of the cell wall by .01 of a millimeter increases the weight of comb one inch thick as much as thickening the midrib .10 of a millimeter.

The thickness of the cell walls is much less than that of the midrib. In natural worker comb I have found it varying between .045 and .07 of a millimeter, with an average of not more than .06 of a millimeter (.0024 of an inch). It has been thought by some that, though the bees may leave a heavy midrib in comb built on foundation, they will thin the cell walls down to the thickness in natural comb.

Although the cell walls of a large number of sections of comb have been measured under the camera of a compound microscope, it is difficult to give these in tabulated form, as there is so much irregularity in thickness. The heaviest part, except the extreme outer end, is close to the base of the cell, and the thinnest is beyond the middle of its length. Where comb on heavy foundations was studied, the bases of the cells were found to have distinctly thickened walls for some distance out, and this thickening was often quite irregular, as may be seen at *o* in Figures *g*, *h*, and *i* of Plate 2, and Figure *b* of Plate 4.

None of the foundations used in the experiment gave as delicately thin cell walls as are found in natural worker comb, except the thin and extra thin super foundations and, possibly, the rather shallow deep-cell foundation put out in 1899, which was placed upon the market by the A. I. Root Co., and which is being sold quite largely this year. I was not able in many cases to detect by measurements that the cell walls on these foundations exceeded the average thickness in natural comb. The difference, if any, is very slight. Figure *g* in Plate 4 shows the thickness of the cell walls of this foundation in cross section, and at *b* of Plate 5 is shown a section of the walls parallel to the midrib and quite close to it. Figure *a* of Plate 5 is a section of fully drawn comb on this foundation, and it will be seen that the cell walls have nearly, or quite, the delicacy of those in natural comb.

The "1898" deep-cell foundation with considerably longer cell walls, as shown at *d* of Plate 4, was not nearly so well worked according to my measurements. This may be due to the fact that the walls are so high that the bees cannot reach to the bottom with their mandibles to take hold of them and pinch them to the natural thinness. They can only thin the lower portion of the walls by scraping them. As a rule, I have found the lower portion of the cell walls of comb on this foundation as thick as those built on the very heavy foundations, while in some cases they have been thinned very nearly to the delicacy of the walls in natural comb. A good illustration of the latter case is shown at the upper half of *a* of Plate 4, but even this sample compared with natural worker comb

shows a difference in favor of the latter which is hardly noticeable in the photographic reproduction. On the other hand, the illustrations of sections of cell walls on this foundation shown at *d*, Plate 3, and at *c* and *f*, Plate 4, show plainly the abnormal thickness of the inner third or half of the cell walls as compared with the walls in natural comb shown in *b*, *c*, and *e* of Plate 3. In fact, a close inspection will show that in many cases the walls of the comb cells seem not to be thinner than the walls in the cells of the foundation before the bees have touched them. In all cases, with this foundation, I have found the walls of the comb cells thicker than in natural worker comb. At *i*, Plate 5, is shown a portion of Figure *d*, Plate 3, somewhat magnified. Notice the thickness of the cell walls in their basal portion.

The cell walls in Figure *h* and the upper half of *i* of Plate 2, and the upper third of *g* in Plate 3, were built on the foundation shown at *f* of Plate 2. The foundation, it will be seen, is almost without walls, yet the bases, at least, of the cell walls in the comb can be seen by the unaided eye to be sensibly thicker than in the natural comb samples.

It seems, then, that keeping the wax out of the cell walls does not entirely remedy the tendency to build heavier bases to the cell walls when plenty of wax is at hand. I do not have a test, however, on strictly "no-wall" foundation, but cannot think the case would be different than in the use of this foundation with such slight walls.

The medium brood and the very heavy foundations also gave cell walls decidedly thicker than those found in natural comb. Examples of cell walls on medium brood foundation are shown at *d* of Plate 2, and at *f* of Plate 5. In the two first mentioned figures the walls are made thinner than in the long drawn cells of the last named example. All are heavier than in natural comb.

At *g* of Plate 2 and *b* of Plate 4 are shown examples of comb on the very heavy foundation. In both cases the greater thickness of the walls is very plainly seen. In the first mentioned figure the heavy walls extend, plainly, the entire length of the cells. Compare with sections of natural comb cells in Plate 3.

These studies indicate that it is a mistake to make very deep cells in artificial foundation, unless their walls can be brought down to the thinness of the naturally built cell walls—which is probably impossible—otherwise, the bees will leave them thicker than in the natural comb. The only cell walls that were brought, practically, to the thinness of the natural comb were those built on foundations with a light base and with little wax in the cell walls. The deep cells may be of advantage in other ways, but not in getting a light comb for section honey.



COMPARATIVE WEIGHTS OF NATURAL COMB AND COMB ON ARTIFICIAL FOUNDATIONS.

There is a third method of studying the effect of foundations upon the resulting comb which, to my mind, gives the most convincing evidence. By this method pieces of natural comb and comb on different kinds of foundation were cut into blocks of known area and carefully weighed. Then the cell walls were removed from the midribs and the weight of these two portions determined separately. Then the weights of the midribs and cell walls of natural comb were compared with the corresponding parts of comb built on artificial foundations, and the midribs of the latter with their corresponding foundation midribs. In this way I was able to determine whether the cell walls or the midribs of comb on artificial foundations were as light as in the natural comb.

*Table Giving Weights, in Grains to the Square Inch, of Whole Comb and of the Midribs and Cell Walls of the Comb, in Each Case Separate.*

| Kind of Foundation.      | Thickness of Comb. | Weight of Comb. | Weight of Midrib. | Weight of Cells. | Sq.ft of Comb to make 1 lb. of Wax. |
|--------------------------|--------------------|-----------------|-------------------|------------------|-------------------------------------|
| Natural Worker Comb..... | 1.37               | 13.00           | 2.20              | 10.80            | 3.74                                |
| " " ".....               | 1.35               | 12.90           | 2.50              | 10.40            | 3.76                                |
| " " ".....               | 1.33               | 12.20           | 2.20              | 10.00            | 3.99                                |
| " " ".....               | 1.25               | 12.80           | 2.30              | 10.50            | 3.80                                |
| " " ".....               | 1.25               | 10.90           | 2.20              | 8.70             | 4.46                                |
| " " ".....               | 1.20               | 9.50            | 2.00              | 7.50             | 5.12                                |
| " " ".....               | 1.18               | 9.60            | 2.15              | 7.45             | 5.09                                |
| " " ".....               | 1.15               | 9.55            | 1.80              | 7.75             | 5.09                                |
| " " ".....               | 1.13               | 9.55            | 2.33              | 7.22             | 5.06                                |
| " " ".....               | 1.00               | 10.00           | 2.50              | 7.50             | 4.86                                |
| " " ".....               | .90                | 9.00            | 2.00              | 7.00             | 5.40                                |
| " " ".....               | .90                | 7.60            | 1.80              | 5.80             | 6.40                                |
| " " ".....               | .80                | 7.00            | 1.80              | 5.20             | 6.94                                |
| " " ".....               | .75                | 6.60            | 1.90              | 4.70             | 7.37                                |
| " " ".....               | .66                | 6.40            | 1.75              | 4.65             | 7.60                                |
| " Drone ".....           | .93                | 10.75           | 3.55              | 7.20             | 4.52                                |
| " " ".....               | .90                | 11.25           | 3.50              | 7.75             | 4.32                                |
| " " ".....               | .88                | 9.90            | 2.80              | 7.10             | 4.91                                |
| Extra Thin ".....        | 1.25               | 11.90           | 2.75              | 9.15             | 4.08                                |
| " " ".....               | 1.22               | 10.61           | 2.33              | 8.28             | 4.58                                |
| " " ".....               | .73                | 7.15            | 3.12              | 4.03             | 6.80                                |
| " " ".....               | .60                | 7.15            | 3.07              | 4.08             | 6.80                                |
| Thin Super (A) ".....    | 1.25               | 13.00           | 2.40              | 10.60            | 3.74                                |
| " " ".....               | 1.25               | 11.50           | 2.60              | 8.90             | 4.23                                |
| " " ".....               | 1.20               | 11.50           | 3.00              | 8.50             | 4.23                                |
| " " ".....               | 1.00               | 10.20           | 2.80              | 7.40             | 4.77                                |
| " " ".....               | .25                | 5.80            | 2.70              | 3.10             | 8.38                                |
| " " (B) ".....           | .90                | 11.50           | 4.00              | 7.50             | 4.23                                |
| " " ".....               | .75                | 9.40            | 3.30              | 6.10             | 5.17                                |
| " " ".....               | .75                | 9.35            | 2.90              | 6.45             | 5.20                                |
| " " ".....               | .75                | 9.10            | 2.70              | 6.40             | 5.34                                |
| 1898 Deep Cell ".....    | 1.46               | 16.80           | 3.60              | 13.20            | 2.89                                |
| " " ".....               | 1.44               | 16.63           | 3.70              | 12.93            | 2.92                                |
| " " ".....               | 1.13               | 14.90           | 3.30              | 11.60            | 3.26                                |
| " " ".....               | .56                | 10.25           | 3.40              | 6.85             | 4.74                                |
| " " ".....               | .50                | 10.00           | 4.00              | 6.00             | 4.86                                |
| 1899 " " ".....          | 1.50               | 14.50           | 2.83              | 11.67            | 3.32                                |
| " " ".....               | 1.31               | 13.33           | 3.33              | 10.00            | 3.65                                |
| " " ".....               | .75                | 11.51           | 3.74              | 7.77             | 4.23                                |
| " " ".....               | .31                | 6.00            | 3.00              | 3.00             | 8.10                                |
| Medium Brood ".....      | 1.30               | 19.50           | 6.87              | 12.63            | 2.49                                |
| " " ".....               | 1.20               | 19.12           | 6.12              | 13.00            | 2.54                                |
| " " ".....               | 1.06               | 16.50           | 6.23              | 10.26            | 2.95                                |
| " " ".....               | 1.00               | 16.50           | 5.50              | 11.00            | 2.95                                |
| " " ".....               | .75                | 12.00           | 5.35              | 6.65             | 4.05                                |
| " " ".....               | .75                | 13.00           | 5.20              | 7.80             | 3.74                                |
| " " ".....               | .38                | 7.50            | 3.50              | 4.00             | 6.48                                |
| *Very Heavy ".....       | 1.00               | 18.50           | 7.00              | 11.50            | 2.63                                |
| " " ".....               | .95                | 18.33           | 8.00              | 10.33            | 2.65                                |

\* This line is an average of pieces composing 15 square inches of comb.

In the preceding table all the weights obtained from the pieces of comb are given.

The first fifteen examples in the table are of worker comb as built by the bees in the natural way. The three following are naturally built drone comb.

The extra thin foundation weighed but 3.60 grains to the square inch, or 13.50 square feet to the pound, and had very slight cell walls. It is shown at *l* of Plate 2 in cross section.

The foundation listed as "Thin Super (A)" weighed almost exactly four grains to the square inch, or a trifle more than twelve square feet to the pound, and was rather firm in texture. It is shown in cross section at *j* of Plate 2.

That listed as "Thin Super (B)" was of the same weight as the preceding, but of softer texture and had more wax in the midrib and less, almost none, in the short walls. It is shown in cross section at *f*, Plate 2.

The "1898" deep-cell foundation is the kind shown at *d* of Plate 4. It ran about 5.46 grains to the square inch, or approximately, nine square feet to the pound.

The "1899" deep-cell foundation is that shown in Figure *g* of Plate 4, and it weighed 5.10 grains to the square inch or 9.53 square feet to the pound.

The medium brood foundation weighed 8.40 grains to the square inch, or 5.80 square feet to the pound. It is shown at *c* of Plate 2.

The very heavy foundation averaged 11 grains to the square inch, or 4.42 square feet to the pound, and is shown at *a*, Plate 2.

The thickness of the comb samples in each case is given in the second column in the table, and is stated in inches and hundredths.

The third column gives the weights in grains to the square inch of the samples used, and is the sum of the weights in columns four and five, which give the weights of the midribs and the cell walls respectively.

The column at the right gives the number of square feet of each sample of comb that would be required to weigh one pound.

Each sample was of whole comb, *i. e.*, comb drawn to a greater or less thickness but not capped, so that the cells were complete as built.

It would have been better, or at least easier, to compare samples of comb of the same thickness; but comb varies so much in this respect that it was found impossible to do so with the samples at hand in the experimental apiary, and the evidence desired seems to be fairly ample in the data obtained and given in the preceding table.

First, I will call attention to the fact that the three samples of drone comb, varying between .88 and .93 of an inch in thickness,



are considerably heavier than samples of natural worker comb of approximately the same thickness.

The sample of comb 1.25 inches thick on extra thin super foundation is but .10 of a grain heavier than the average of the two samples of natural comb of the same thickness. The sample 1.22 inches thick is fully as light in proportion to its thickness. The two thinner comb samples on this foundation do not compare quite as favorably with the natural.

The thickest sample of natural comb measured 1.37 inches, and weighed 13 grains to the square inch. No sample on artificial foundation as thick weighed so little, while one sample 1.25 inches thick on thin super foundation (A) weighed the same. All samples over .75 of an inch thick on medium brood and very heavy foundations weighed from about one-fourth to two-thirds heavier, or from 16.50 to 19.50 grains to the square inch. The sample 1.13 inches thick on deep-cell foundation put out in 1898 exceeds in weight the thickest sample of natural comb by 1.9 grains to the square inch.

The samples of natural comb 1.34 and 1.33 of an inch thick are also exceeded in weight by the same thinner samples of comb on artificial foundations just mentioned.

The heavier sample of natural comb measuring 1.25 inches thick is exceeded in lightness by one sample of comb on thin super foundation of the same thickness, while the other sample of the latter is heavier than the natural.

The two thickest samples of comb on "1898" deep-cell foundation average one-seventeenth thicker than the thickest sample of natural comb, but their weights average more than one-fourth heavier than those of the latter. Their comparison with the next two samples of worker comb would be still less favorable to the foundation.

The sample of natural comb measuring 1.13 inches thick seems not to be unusually light, as the sample 1.15 thick weighed no more; the one that was 1.18 thick hardly exceeded it, and the one 1.20 thick weighed even less. Comparing this comb with the sample of the same thickness on the "1898" deep-cell foundation, we find the latter is heavier than the former by more than one-half the weight of the natural comb. In other words, it is heavier than the natural comb by almost exactly the weight of the deep-cell foundation. The two samples of comb on this foundation that are .60 and .56 of an inch thick respectively are as heavy or heavier than any of the samples of natural worker comb measuring from 1.20 inches in thickness down.

The "1899" deep-cell foundation produced a comb much nearer the natural in lightness. Comparing the sample 1.50 inches thick with the natural sample 1.37 thick, we see there is but 1.50 grains difference in weight, which would be fully accounted for by the greater

thickness of the comb in the case of the latter. Comparing with the two thickest samples of comb on the "1898" deep-cell foundation, either of which is thinner than the "1899" sample, we notice that the latter is, nevertheless, considerably lighter in weight.†

If we compare the sample of comb 1.31 inches thick on the "1899" deep-cell foundation with the samples of natural comb measuring 1.33 and 1.35 inches respectively, we find a good margin of difference in favor of the natural samples, although they are somewhat thicker than the example on foundation.

These comparisons bring us again to the conclusion that, of the samples of foundation that we have studied, the thin and extra thin super, and the "1899" deep-cell foundations, are far the best for the production of a comb to compare in quality and lightness with natural comb.

\* Now, if we examine columns four and five we shall see that the increased weights of the examples of comb on artificial foundations were due more to the extra wax in the cell walls than to the increased amount of wax in the midribs in cases of the heavy foundations, but not in cases of the thin and extra thin super, or "1899" deep-cell foundations. I will call attention to a few examples and the reader may compare others.

Beginning with the heaviest foundations first, it will be seen that the comb cells in the sample one inch thick weighed 11.50 grains, against 7.50 grains in the case of the natural comb of the same thickness. In case of comb one inch thick on medium brood foundation, the cells weighed 11.00 grains to the square inch.

Take the samples of the same kinds of comb that are .75 of an inch in thickness and the weights of cell walls are, for natural comb, 4.70 grains; for comb on medium brood foundation, 6.65 grains; and for comb on very heavy foundation, 7.80 grains. It will also be noticed that the two samples of comb on "1898" deep-cell foundation that were less than .75 of an inch thick had cell walls that were considerably heavier than the natural comb that was of that thickness.

If we combine the two samples of medium brood comb, one measuring 1.30 and the other 1.20 inches thick, we shall have an average of a sample 1.25 inches thick, the cells of which weigh 12.81 grains to the square inch. Comparing this with the weights of the cells of the natural comb samples of the same thickness, we find it exceeds the heavier by 2.31 grains, and is almost one and one-half

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\* In "A, B, C of Bee Culture," p. 67, Mr. E. B. Weed is reported to have discovered "That in ordinary foundations upon the market, there was too much wax in the base (midrib) and not enough in the wall; that whenever the base is thicker than the bees make it they will rarely take the trouble to thin it down; but, no matter how thick the wall, they will invariably thin it down to the thickness of the natural." Both these statements need to be much modified, according to the experiments here reported.



times the weight of the lighter. It even exceeds the weight of the thickest of the natural comb samples by 2.01 grains.

If we take the comb cells on "1898" deep-cell foundation that measured 1.13 of an inch thick and compare their weight with the sample of like thickness of natural comb, we see that the cells of the latter are lighter by 4.38 grains. In fact the cell walls of this sample of deep-cell foundation exceed in weight any of those of the seven thicker samples of natural comb.

The comb samples on the "1899" deep-cell foundation had cell walls that compare very favorably with the natural comb in lightness. The comb 1.31 inches thick on this foundation had cells that weighed exactly the same as cells of natural comb that was 1.33 inches thick, and the cells from the sample 1.50 inches thick did not weigh more than would be expected for natural comb. The sample of comb .75 of an inch thick on this foundation does not compare so favorably in weight of its cells.

If we pass to the comb on thin super foundations we again find very satisfactory comparisons. The cells from comb 1 inch thick and from comb 1.20 inches thick weighed only a trifle more from the foundation than from natural comb. The same is true of the average of the two samples in each case that were 1.25 inches thick. The differences being so slight, go to show that there is practically no difference in the weight of cell walls of natural comb and comb of the same thickness on the thin super foundation.

The samples of comb on extra thin foundation compare equally well with natural comb in the lightness of their cell walls, as may be seen by the table.

By comparing the weights of the comb midribs given in column four, it will be seen that the lightest midribs from comb on foundation are not quite as heavy as the heaviest midribs in natural worker comb, but in every case they are heavier than the average weight (2.10 grains to the square inch) of the midrib of natural comb.

With this additional evidence, it seems impossible to avoid the conclusion that heavy foundations result in combs heavier than the natural, and that the increased weight is due both to thicker midribs and heavier cell walls, but much more to the latter than to the former in cases where heavy foundations are employed, even though much wax is left unused in the midrib.

The experiments show that to get a light comb, approaching that which the bees naturally build, there must not be a large amount of wax in either the midrib or cell walls of the foundation.

The evidence is also quite conclusive that if the cell walls are very high, as in the "1898" deep-cell foundation, they will not often be well thinned in the building of the comb.

TO WHAT EXTENT DOES THE FOUNDATION LESSEN THE SECRETION OF  
WAX BY THE BEES?

Let us begin with the comb built on the heavier foundations and compare with the naturally built worker comb, to determine the effect on wax secretion.

Natural worker comb 1 inch thick weighed 10.00 grains to the square inch. The very heavy foundation alone weighed 11.00 grains, or 1 grain more than is necessary to build the comb to that thickness. But when comb was built on this thick foundation, it weighed 18.50 grains, so that the bees added 7.50 grains to the square inch to the foundation that itself contained more wax than was necessary to build the comb. As natural comb weighs but 10.00 grains to the square inch, the bees lacked but 2.50 grains of furnishing as much wax as they would have done if they had built the comb without the foundation. \*It is seen that 11.00 grains of wax were furnished the bees in order to save them the expense in food and labor of producing 2.50 grains.

In case of the medium brood foundation weighing 8.40 grains to the square inch, the result was similar. The bees needed to add but 1.60 grains to this to build the comb one inch thick, but they did add 8.10 grains, making a comb weighing 16.50 grains to the square inch. As the amount added in this case is only 1.90 grains less than the weight of the natural comb of the same thickness, it cost the whole weight of the foundation, or 8.40 grains, to save the bees from secreting 1.90 grains of wax.

As another illustration with this same foundation, take the samples drawn to .75 of an inch. The average weight would be 12.50 grains. This is 5.90 grains more than the weight of samples of natural comb drawn to the same thickness, and 4.10 grains more than the weight of the foundation alone, notwithstanding the fact that the foundation as given the bees contained 1.80 grains to the square inch more wax than was necessary to build natural comb to that thickness. In other words, the bees were furnished more wax than was necessary to build the comb three-quarters of an inch thick, and yet they added to this amount more than nine-tenths as much wax as they would have used to build the comb without foundation.

Passing now to the Weed deep-cell foundation manufactured in 1898, we find results fully as surprising. If we compare the sample measuring 1.13 inches thick with natural comb of the same thickness, we find that the latter is lighter by 5.35 grains. As the foundation itself weighed only 5.46 grains to the square inch, the indication is that the bees used as much wax from their own secret-

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\* Cheshire says "Bees very rarely work more than half their cell walls out of even the stoutest sheets given them."—*Bees and Bee Culture*, V. II., p. 216.



Table Giving the Proportionate Weights of Honey and Wax in Capped Comb Honey.

| KINDS OF COMB.                               | Thickness in Inches. | Total Weight in Grams. | Weight of the Honey in Grams. | Weight of Wax only in Grams. | Proportion of Wax to Honey. |
|----------------------------------------------|----------------------|------------------------|-------------------------------|------------------------------|-----------------------------|
| Natural . . . . .                            | 1.37                 | 308.45                 | 297.95                        | 10.50                        | 1 to 28.38                  |
| “ . . . . .                                  | 1.13                 | 174.00                 | 167.71                        | 6.29                         | 1 to 26.66                  |
| “ . . . . .                                  | .75                  | 75.00                  | 71.14                         | 3.86                         | 1 to 18.43                  |
| On Small Starter. . . . .                    | ....                 | 374.00                 | 356.76                        | 17.24                        | 1 to 20.70                  |
| “ “ “ . . . . .                              | ....                 | 351.00                 | 334.40                        | 16.60                        | 1 to 20.02                  |
| “ “ “ . . . . .                              | ....                 | 346.00                 | 330.40                        | 15.60                        | 1 to 21.12                  |
| “ “ “ . . . . .                              | ....                 | 344.20                 | 328.50                        | 15.70                        | 1 to 20.92                  |
| “ “ “ . . . . .                              | ....                 | 344.00                 | 328.19                        | 15.81                        | 1 to 20.76                  |
| “ “ “ . . . . .                              | ....                 | 312.80                 | 298.00                        | 14.80                        | 1 to 20.13                  |
| “ “ “ . . . . .                              | ....                 | 287.00                 | 273.20                        | 13.80                        | 1 to 19.80                  |
| On Full Piece '99 Deep-Cell Starter. . . . . | .. .                 | 544.00                 | 525.08                        | 18.92                        | 1 to 27.75                  |
| On Full Piece '98 Deep-Cell Starter. . . . . | ....                 | 404.00                 | 384.00                        | 20.00                        | 1 to 19.70                  |

In case of natural comb honey 1.37 inches thick the honey weighed 28.38 times as much as the wax, while the sample .75 of an inch thick, which was built at the same time as the thicker comb and by the side of it, had only 18.43 times as much honey as wax. The intermediate sample (1.13 inches thick) had 26.66 times as much honey as wax.

All other comb samples in this table were taken from sections measuring 4¼x4¼ inches and 1¾ inches thick. The combs were built on small top starters, except in case of the last two examples, one of which was built upon a full-piece of the “1899” deep-cell foundation and the other upon a similar sheet of “1898” deep-cell foundation. The thickness of the comb was not taken in these sections, but it did not vary much from one and one-fourth inches in any case.

The comb in the sections with small starters did not vary much from one-twentieth of the weight of honey in any case, and the proportion of wax was somewhat greater than in the samples of natural comb of similar thickness.

Passing to the sample of comb on the “1899” deep-cell foundation, we notice, first, that it is much heavier than any of the preceding, and hence much thicker, and in consequence it has a much higher ratio of honey to wax, 1 to 27.75. This is also in keeping with results announced on previous pages, indicating that this

foundation is drawn out by bees into a comb approximating the lightness of the natural product.

In contrast to this last example, but also in harmony with results given on preceding pages, notice that the "1898" deep-cell foundation gave a comb heavier than the preceding, though the honey weighed less by more than one-fourth. The proportion of wax to honey was greater in this case than in any of the others, except that of natural comb only .75 of an inch thick. It should have given a larger proportion of honey than any of the samples built on small starters, as the comb in the latter was thinner in every case.

From the facts given in the above table, it is evident that if we are to secure a comb honey with the least possible amount of wax, it will be necessary to have it built in sections that will secure the greatest thickness of comb. In this way we can also economize very considerably the labor and energy of the bee in wax secretion and comb building.

Attention might also be called to the fact that it takes more wax and more work for the bees to cap ten pounds of honey in thin comb than in thick comb.

The reader will not understand that I am advocating the use of deep sections; there may be other reasons why they are not preferable; I am only mentioning points which, according to my experiments, favor thin sections.



## SUBSTITUTES FOR POLLEN.

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It is a well known fact among bee-keepers that bees can be stimulated to early brood rearing in spring by putting out some kind of finely ground meal or flour, which they take as a substitute for pollen. Writers vary in their opinions as to what is the best, but it is commonly recommended to use rye, oats, or pea meal. Common wheat flour, wheat middlings, corn meal, barley meal, and malt all have their advocates. It was thought best to put out at one time a good number of these substitutes for the purpose of determining which would be given the preference by the bees. To do this a number of boards were laid flat upon the ground in the vicinity of the apiary, a small pile of each kind of meal put upon them and notes taken upon the results.

It was found that any of the substances used would be taken freely when used alone. Also that the preference did not always go to the same feed.

Results with the first series of tests were published in the Seventh Annual Report of this Station. As that report did not reach a large number of general readers, and as subsequent tests lead to some change in the order of preference, I have thought it best to report upon the work again here. The order of preference as nearly as could be judged ran as follows: Ground whole kernels of oats, corn, and wheat, fine wheat bran,\* cleaner dust,† cotton-seed meal, wheat bran, pea meal, wheat flour, rye flour, bean meal, barley meal. The three last named they would hardly touch as long as others were accessible.

As pollen furnishes the bees with nitrogenous food, it seems probable that those substitutes for pollen that have most nitrogen, or rather, that furnish the chemical compounds most nearly in the proportions that they are found in pollen, would be best suited to take the place of pollen in the dietary of the bee.

In order to determine whether or not the chemical composition of the food-stuffs best liked by the bees were more like the composition of pollen than the others, I had a quantity of corn pollen col-

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\* Bran ground over so as to be fine.

† Waste dust and chaff as taken from cleaners at flouring mill.

lected and taken to Dr. W. P. Headden, Station Chemist, for analysis. In the table below the first analysis is that of corn pollen made by Dr. Headden, and the analyses of the other materials are compiled :

| NAME.                 | Water. | Ash.  | Crude Fibre. | Fat.  | Protein. | Nitrogen Free Extract. |
|-----------------------|--------|-------|--------------|-------|----------|------------------------|
| Corn Pollen.....      | 3.444  | 5.039 | 7.970        | 1.526 | 19.598   | 62.423                 |
| Oats Ground.....      | 9.3    | 3.5   | 8.5          | 3.6   | 11.4     | 63.7                   |
| Corn " .....          | 13.6   | 1.4   | 1.9          | 3.4   | 9.6      | 70.1                   |
| Wheat " .....         | 11.5   | 2.0   | 2.9          | 2.0   | 12.1     | 69.5                   |
| Wheat Bran.....       | 11.0   | 5.7   | 10.4         | 5.0   | 15.9     | 52.0                   |
| Cotton-seed Meal..... | 8.0    | 6.9   | 6.7          | 10.0  | 42.0     | 25.7                   |
| Pea Meal.....         | 8.8    | 2.6   | 17.7         | 1.6   | 19.2     | 50.1                   |
| Wheat Flour.....      | 12.6   | 0.7   | 0.7          | 1.2   | 11.8     | 74.1                   |
| Rye Flour.....        | 14.0   | 1.6   | 1.5          | 1.6   | 10.5     | 72.5                   |
| Bean Meal.....        | 12.0   | 1.4   | 2.1          | 8.5   | 11.0     | 65.0                   |
| Barley Meal.....      | 13.1   | 2.4   | 5.7          | 1.9   | 11.3     | 65.6                   |

It will be noticed that, while the nitrogenous material (protein) is high in the pollen, it is not very high in some of the flours best liked by the bees, as for example, corn and oats. Cotton-seed meal runs very high in protein and was not specially liked.

So there are, doubtless, other reasons than the amount of nitrogenous food material, that influence the bees to take substitutes for pollen. It is probable that the aroma and mechanical qualities may have much to do in determining their choice. There is nothing very definite in the above order of choice of the different foods used. The order will often vary on consecutive days, or even on consecutive hours.

It is by no means certain that the flour the bees like best is best for them, for this manner of supplying them nitrogenous food is entirely artificial. The best substitute for pollen is that food which the bees will take and upon which they do best, and it seems probable that it will have a chemical composition approximating that of natural pollen.



## SUMMARY OF MORE IMPORTANT CONCLUSIONS.

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1. Bees use freely the wax in foundation to extend both the midrib and the cell walls of honey comb.

2. The heavier the foundation used, the heavier, as a rule, will be the comb built upon it.

3. If the midrib of a foundation is much lighter than that of natural comb, the bees are likely to strengthen it by adding wax to the bottom of the cells.\*

4. If the midrib of the foundation is thicker than the midrib of natural comb, it will result in a comb with a midrib thicker than the natural. Or, to state it differently, the bees will not thin the midrib of a foundation down to the thickness of worker comb built in the natural way.

5. Midribs of foundation that are not more than .17 of a millimeter (.007 inch) in thickness, are thinned little or none by the bees.

6. Drone comb has a thicker midrib and heavier cell walls than worker comb.

7. A foundation with a heavy midrib and very slight cell walls, will still produce a comb with heavy cell walls.

8. Very high cell walls in foundation are not cut down to the thinness of cell walls in natural comb.

9. The thin and extra thin and the "1899" deep-cell foundations produce a comb that approximates very closely the lightness of that which is naturally made by the bees.

10. When heavy foundations are used, the extra weight of the comb built upon them is due more to the extra weight of the cell walls than to the heavier midrib.

---

\* Possibly this is only done where there are actual perforations of the comb.

11. When very light foundations are used, the somewhat heavier comb is due almost entirely to the midrib being heavier than that of natural comb.

12. When foundations containing an abundance of wax to build the entire comb are used, the bees still add much more wax, sometimes nearly enough to build the comb without the help of the wax in the foundation.

13. Wax seems to be given with the best economy when the midrib of the foundation is of the thickness of the midrib of natural comb, and when there is a small, or at most a moderate, amount of wax in the cell walls.

14. Poorly attached combs in sections seem to be more the result of weak colonies and poor honey flow than to the kind of starter that is used; though large starters and strips of foundation in the bottom of the sections do help to strengthen the union of comb to the section.

15. Separators between the sections are essential to the best results in producing comb honey.

16. The thicker the comb, whether natural or artificial, the greater the proportion of honey to wax in it.

17. In natural worker comb, one inch thick, the proportion of wax to honey is between 1 to 20 and 1 to 25 by weight.



## EXPLANATION OF PLATES.

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### PLATE 1.

*a*, blackened super foundation; *b*, sections of comb built on a strip of blackened foundation as shown at *a*; *c*, comb built on narrow strip of foundation as shown at *a*; *d*, fully drawn comb built on full-piece starter of black foundation; *e*, midrib of natural worker comb after removing the cells; *f*, midrib of comb built on "1898" deep cell foundation; *g*, comb that the bees have just begun to draw on medium brood foundation, enlarged about two diameters; *h*, like the preceding except that the cells are fully drawn.

### PLATE 2.

*a*, cross-section of very heavy foundation; *b*, midrib of comb built on very heavy foundation in upper two-thirds, the lower third being natural midrib extended by the bees; *c*, cross-section of medium brood foundation; *d*, like the preceding except that the bees had begun to draw out the cells in the upper two-thirds of the figure; *e*, the same as *d* with the cells farther drawn; *f*, a rather heavy super foundation blackened with lamp-black; *g*, section of comb on heavy foundation shown at *a*; *h*, comb on foundation shown at *f*; *i*, the upper two-fifths like *h* and the remainder natural drone comb; *j*, section of thin super foundation; *k*, the same as the preceding with the cells partly drawn; *l*, section of extra thin foundation.

### PLATE 3.

*a*, section of comb on thin foundation in upper half, natural comb in lower half; *b*, natural comb; *c*, natural comb cut from side to side of a section of honey; *d*, comb built on "1898" deep-cell foundation; *e*, cells of natural worker comb cut in cross-section; *f*, cells of natural drone comb in cross-section; *g*, cells of worker comb in cross-section, the upper one-third of which was built on the foundation shown at *f* of Plate 2, and the rest is natural.

### PLATE 4.

*a*, cross-section of comb cells, the upper third of which were built on "1898" deep-cell foundation; *b*, cross-section of worker

comb built on very heavy foundation; *c*, section of comb built on "1898" deep-cell foundation; *d*, section of "1898" deep-cell foundation; *e*, cross-section of the cells of "1898" deep-cell foundation before being worked by the bees; *f*, section of comb on the "1898" deep-cell foundation; *g*, section of "1899" deep-cell foundation; *h*, partly drawn comb on the preceding foundation.

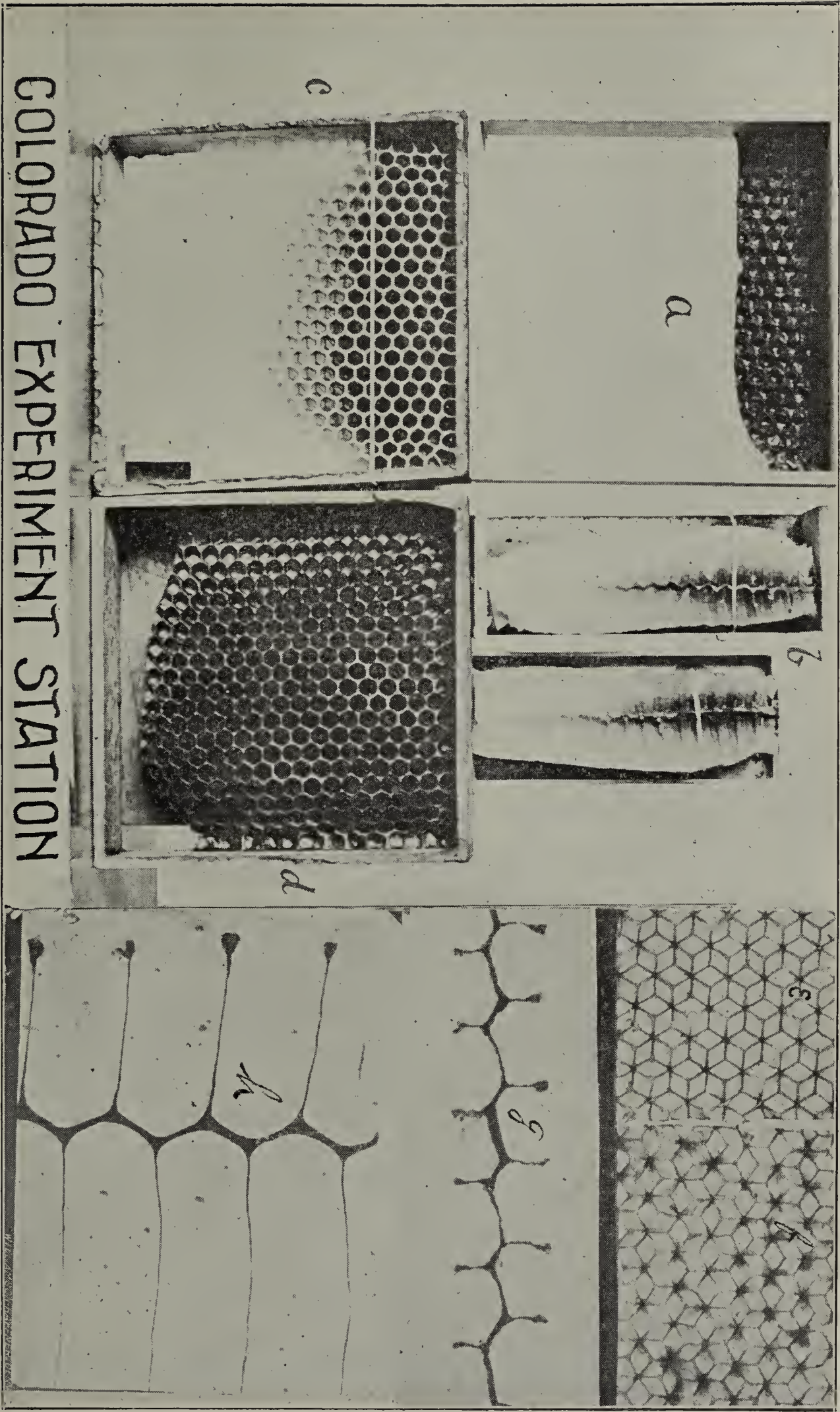
PLATE 5.

*a*, section of comb on "1899" deep-cell foundation; *b*, cross-section of cell walls of the "1899" deep-cell foundation before they have been worked at all by the bees; *c*, section of the Weed "thin-base-and-heavy-wall" foundation; *d*, section through comb to show that the midrib can be cut so as to give a straight line; *e*, another sample of comb manufactured by Mr. Weed with extremely thin midrib and high and heavy walls; *f*, comb on medium brood foundation; *g*, comb on extra thin super foundation; *h*, sections of honey showing how comb is bulged when separators are not used; *i*, comb on "1898" deep-cell foundation somewhat magnified, showing the heavy basal portion of the cell walls.

PLATE 6.

*a* to *g*, different methods of using starters in sections; *h*, *i* and *j*, showing how comb is built on starters that fill the sections half way down; *k*, *l* and *m*, showing method of building down comb from small starter; *n*, comb built on a full-piece starter; *o* and *p*, the way sections are finished in weak colonies or during a poor honey flow, particularly with small-piece starters; *q* and *r*, large piece starters that the bees have gnawed away during dearth of honey; *s*, the way sections should be finished.





COLORADO EXPERIMENT STATION

PLATE 1.

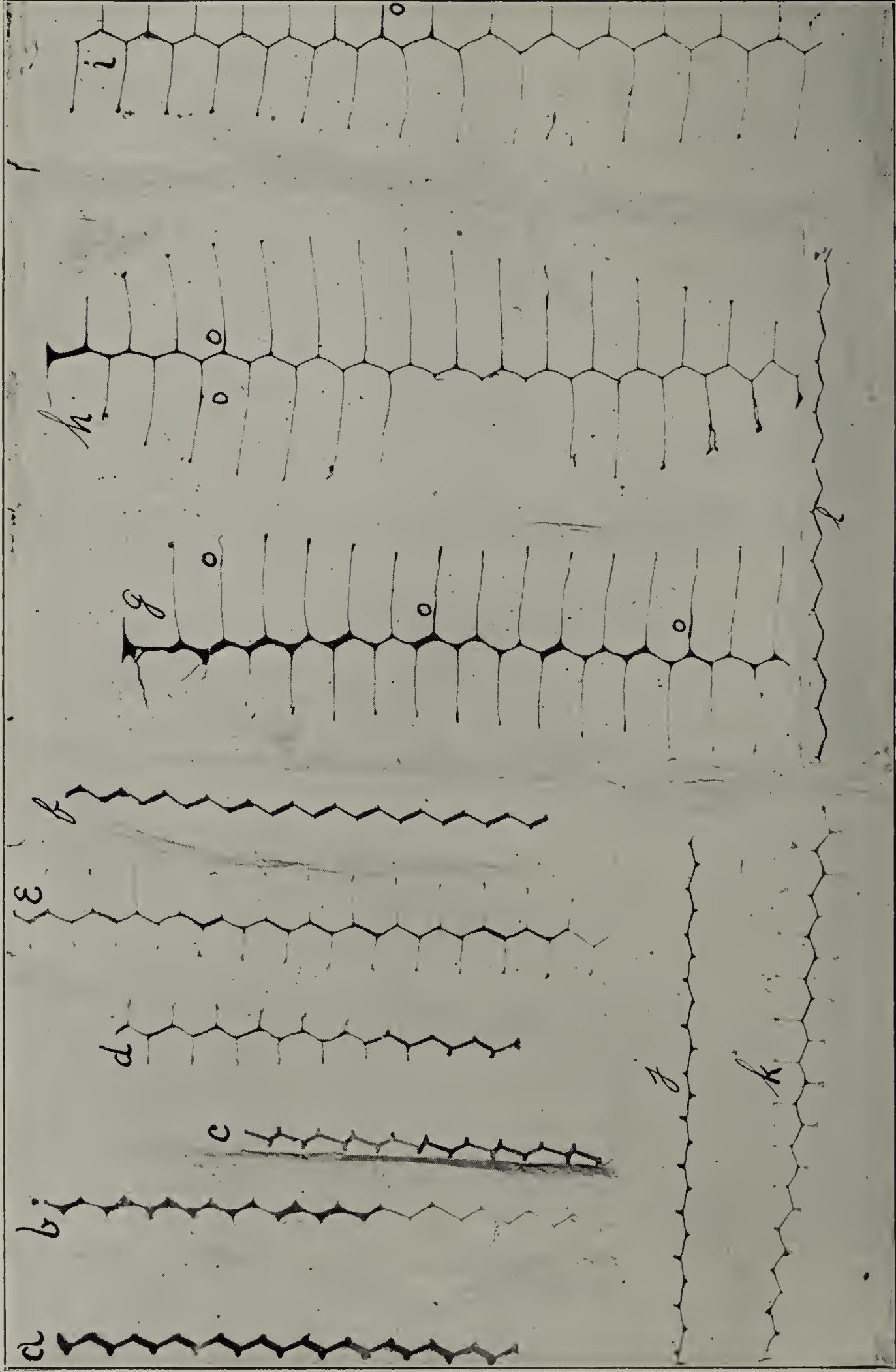
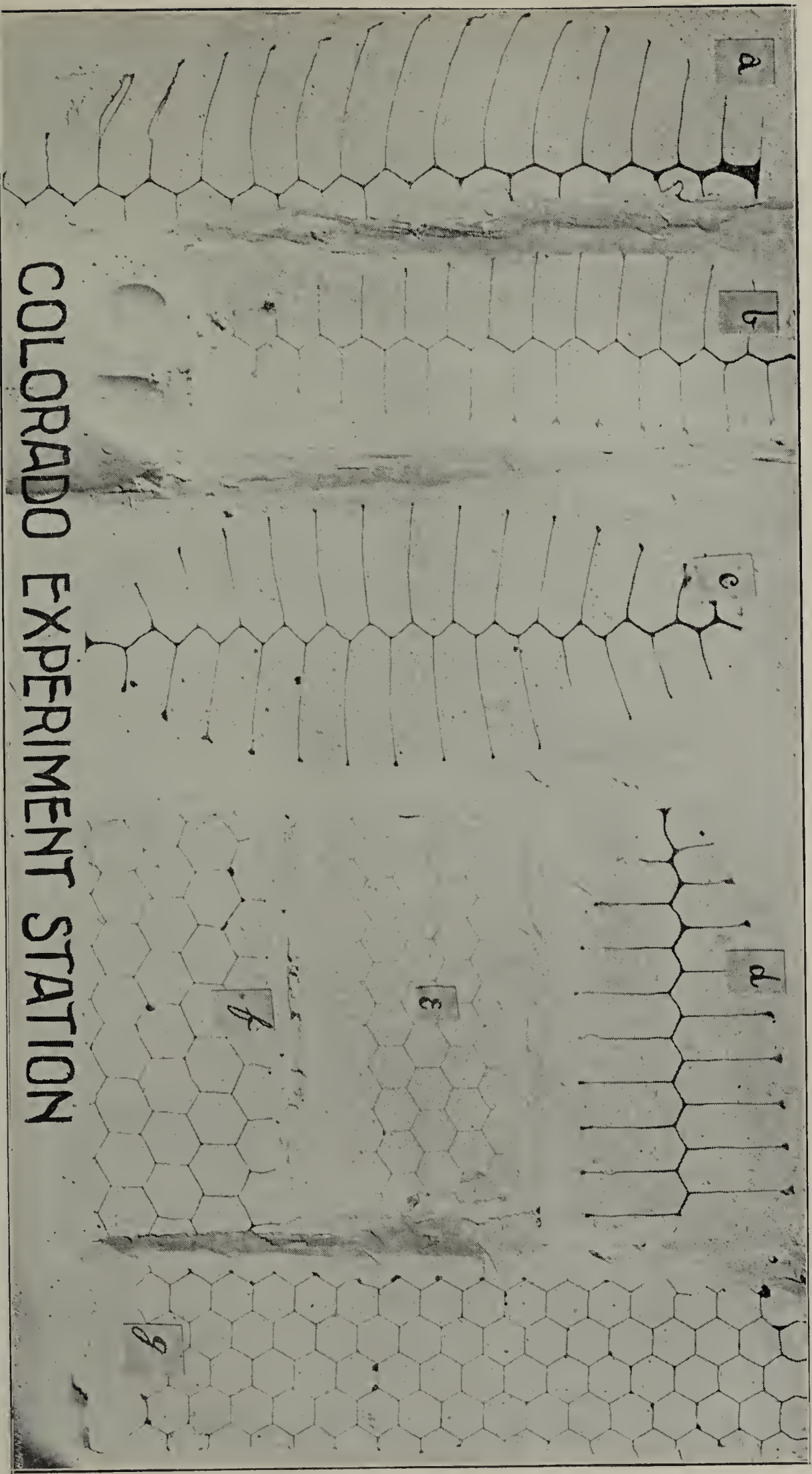


PLATE 2.





COLORADO EXPERIMENT STATION

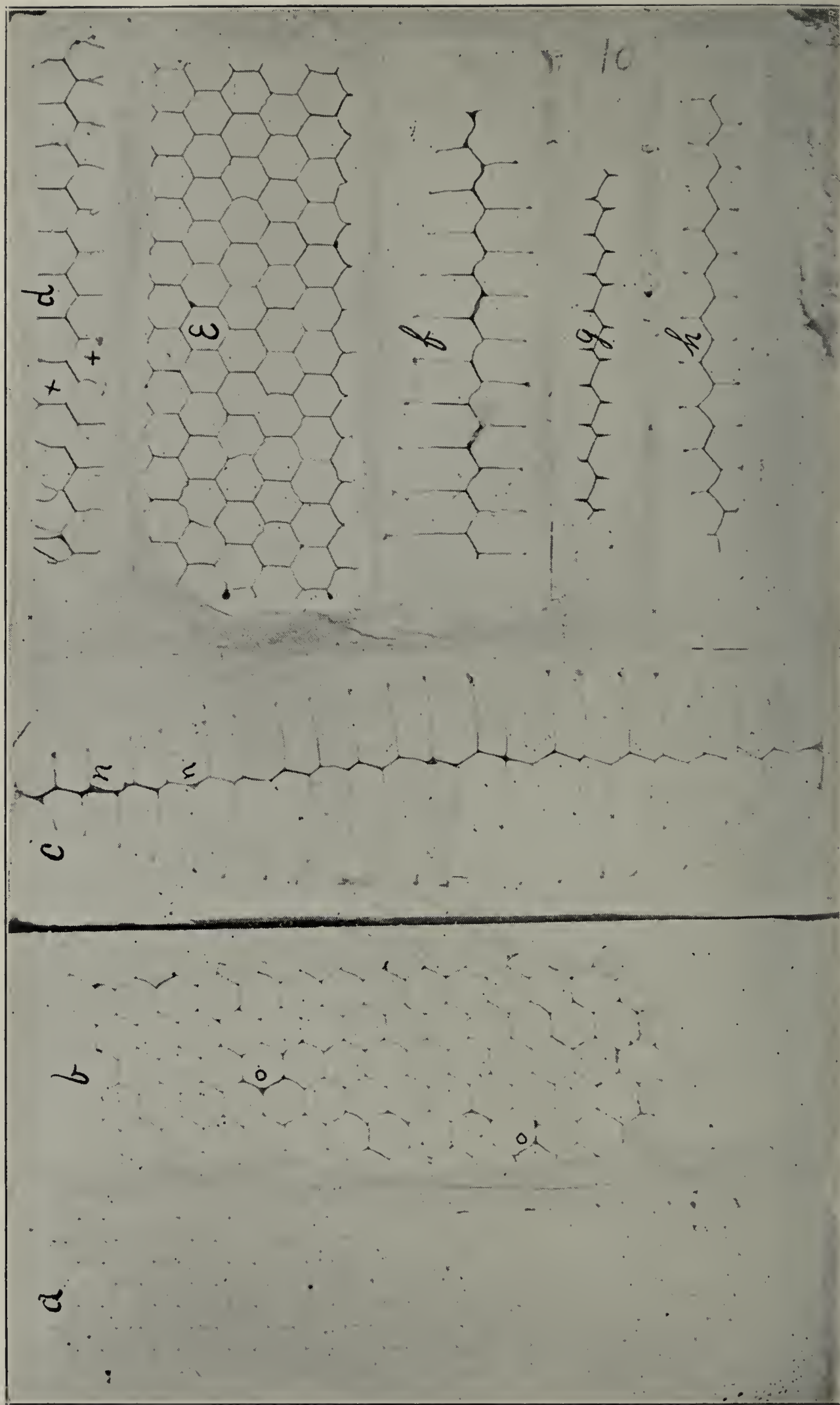


PLATE 4.



ing within .11 of a grain, as they would have done if no foundation had been given.

The samples of comb .56 and .60 of an inch thick on this foundation contain enough wax to make a natural comb one inch thick, and nearly half of the weight was added by the bees.

Reliable results are not so readily obtained in the study of comb samples on the light foundations, as the amount of wax in them is small and the natural variation in comb samples is considerable.

The thickest sample on the thin super foundation (B) was only .90 of an inch. To get as near an average weight of the natural comb as possible for comparison, let us combine the two examples that measure .90 of an inch each with those measuring respectively 1.00 and .80 of an inch. The average would be 8.40 grains to the square inch. The difference between this and the sample on this foundation is 3.10 grains. As the foundation itself weighed 4.00 grains to the square inch, the indication in this case is that the saving to the bees was the difference between these weights, or .90 of a grain to a square inch, or about 23 per cent. of the amount of wax given.

Far better results were obtained in the use of thin super foundation (A), the average weight of which was 4.07 grains to the square inch.

Comparing comb 1 inch thick on this foundation with natural comb of the same thickness, we find, in case of one of the samples in the table, there is but .20 of a grain difference in favor of the latter. This means that this foundation lessened the amount of wax that the bees secreted, by 95 per cent. of its own weight.

The above may have been rather an exceptional piece on the thin foundation. If we compare the sample that measured 1.20 inches in thickness with a similar sample of natural comb, we find a difference of 2 grains to the square inch. As the foundation was almost exactly twice this weight, it indicates that the bees were relieved from secreting an amount of wax equal to half the weight of foundation given.

It is important to notice that to build the comb on this foundation to the thickness of 1.20 inches, the bees added the difference between 11.50 and 4.07 grains to the square inch, which would be 7.43 grains, and this is actually less than they added in cases where they built comb to a thickness of only one inch on the very heavy and the medium brood foundations, and to a thickness of 1.13 inches on the deep-cell foundation, though in any one of these last three cases they were furnished more wax to start with.

Again, if we take the average of the two samples of comb on this thin foundation that were 1.25 inches thick and compare it with an average of the two samples of natural comb of the same thickness, we find that the latter is .40 of a grain lighter to the square inch

than the former. This would indicate that 90 per cent. of the foundation was utilized by the bees in making a comb but slightly heavier than the natural. We also find that the bees actually added less to this foundation in order to draw it out to 1.25 inches in thickness than in cases where they built comb to a thickness of an inch on the heavy and medium brood foundations. Further experiments are needed bearing upon this point.

If we compare the comb built on the "1899" deep-cell foundation and the extra thin super foundation with the natural comb, we find results nearly, or quite as good as the preceding. For examples, the comb 1.31 inches thick on the deep-cell foundation was but 1.13 grains heavier than the natural sample 1.33 inches thick, and the sample on this foundation that was 1.50 thick exceeded the weight of natural comb 1.37 inches thick by only 1.50 grains.

In case of the comb on extra thin foundation, the sample that was 1.22 inches thick weighed but 1.11 grains to the square inch more than the natural sample that measured 1.20 inches thick; and the sample on this foundation 1.25 inches thick is almost exactly an average of the two pieces of natural comb of the same thickness.

It seems, then, from all the evidence furnished by the forty-nine samples of comb listed in the preceding table, that we do not lessen the wax secretion of the bees much, if any, more when we furnish them a heavy foundation than when we furnish them a very light foundation.

These differences between the heavy and light foundations for comb building seem quite remarkable, and in a large series of samples might not result so much in favor of the light foundations; but the samples recorded in the table were taken without any attempt or thought of favoring one form or weight over another.

The writer believes it is a matter of much importance to beekeepers to produce comb honey with as small an amount of wax as possible. They will, in this way, increase the consumption of their product, as many people object to comb honey because of the large amount of wax they often find in it.

#### METHODS OF USING FOUNDATION IN SECTIONS.

It is necessary to use some foundation in sections for comb honey. The best size and form of the piece of foundation to be used as a "starter" is not universally agreed upon, some preferring one form and some another.

The different methods of applying these starters, shown in Figures *a* to *g* of Plate VI., have been tested in the College Apiary for the past three years.

There was no appreciable difference in the comb produced by using starters in the manners shown by Figures *a*, *c* and *d*. The only advantage in the long, narrow piece, shown at *e*, was that it had



a tendency to secure the building of worker comb throughout. It has one disadvantage, and that is its large size and short line of attachment, so that if it is not well secured at the top the bees are liable to cluster upon it and pull it loose. The long, narrow piece placed across the top of the section, Figure *f*, has given rather better results than any of the preceding, as the bees usually attach it quickly at the ends, thus closing the top corners. I have also used many starters like the preceding, but extending about half way down. Figures *h*, *i* and *j* represent comb on such starters. It will be noticed there are no holes in the upper corner or sides. At *n* is a section of comb built on a full-sized starter, as shown at *g*. It will be noticed that the comb cells are all uniform in size and the comb evenly filled out. Such comb when filled and capped, is handsome in appearance, like the samples shown at *s*, and brings the highest market price. In my experiments the sheets that extended half way down gave as good results as those that filled the section. The use of small pieces of foundation in the lower corners, as shown at Figure *c*, gave no beneficial results.

The use of short strips of foundation in the middle of the bottom of the section, as shown at *b*, has resulted in somewhat better attached combs at the bottom of the section, especially during a slow honey flow.

Figures *k*, *l* and *m* show how comb is usually extended from a small piece of foundation, leaving, very often, holes in both upper corners. If the honey is coming in slowly and the colony is not very strong, the sections are liable to be finished like the two shown at *o* and *p* of the same plate. Not only are these sections light in weight and slow to sell, but they will not ship well, for the jar of handling will break many from their attachments in the sections. I have found, however, that such sections of honey are due much more to a weak condition of the colony and a poor honey flow than to the manner of using foundation. Under such conditions even large pieces of foundation are often gnawed away, as shown at Figures *q* and *r*. When the colony is strong and the honey flow good, small pieces of foundation, like the one shown at *a*, will often produce just as finely filled sections as can be obtained from full-sized pieces with strips below. Moral: Keep the colonies strong.

Comb built upon foundation is always tougher and more waxy than the natural comb, and a cross-section will show that the mid-rib and bases of the cells are darker in color. So that while the large pieces of foundation result in a somewhat finer appearing capped honey, the small starters will result in a more delicate and brittle comb.

#### ADVANTAGES FROM THE USE OF SEPARATORS.

Most producers of comb honey recognize the advantage in the use of thin strips of wood or tin between the rows of sections in the

supers. Without them the comb is sure to be uneven in a large proportion of the sections, and in many cases it will be bulged so as to make it very difficult to pack the sections in a crate for shipment. Illustrations of such sections are shown at *h* of Plate 5. These sections also vary much in weight, some weighing considerably more than a pound, while others weigh as much less. They are not as attractive nor as easily handled upon the market as those that are built with flat faces that do not project beyond the edges of the section, and that are all uniform in weight and appearance, as shown at *s* of Plate 6. I have used the tin and board separators in about equal numbers and have been unable to see that one has any special advantage over the other.

I have also used separators upon one side and upon both sides of the sections. While very good sections of honey are obtained by the use of separators upon one side only, the results have been enough better when used upon both sides to make the latter plan advisable. In my experiments the sections that had no separators averaged one-half ounce more in weight than those with separators on one side only, and the latter weighed one-half ounce more than the sections that had separators on both sides. As these lighter, better appearing sections sell better than the heavier, ill appearing ones, there is a double advantage in their production.

#### PROPORTION OF WAX IN COMB HONEY.

Beeswax does not melt at the temperature of the body and is indigestible in the human stomach. Although this does not necessarily imply that beeswax is harmful in food, it becomes a matter of some interest to know how much wax is taken with ordinary comb honey when the latter is eaten. It is also a matter of interest to know how much wax the bees are compelled to secrete for every pound of honey that they store in the natural way.

As a thick comb has but one midrib, and as the walls of the cells are heavier near the midrib than they are towards their outer portions, it is evident that comb one and one-half inches thick would not be half heavier than comb one inch thick. The increased weight of the thicker comb would be due entirely to the additional wax required to extend the walls of the cells one-half inch, and to that only. On the other hand, it is equally evident that the honey filling a comb one and one-half inches thick would weigh half more than honey filling a comb one inch thick. Consequently the weight of wax in thick combs is less in proportion than in thin combs. The weights given in the following table shows this to be true:



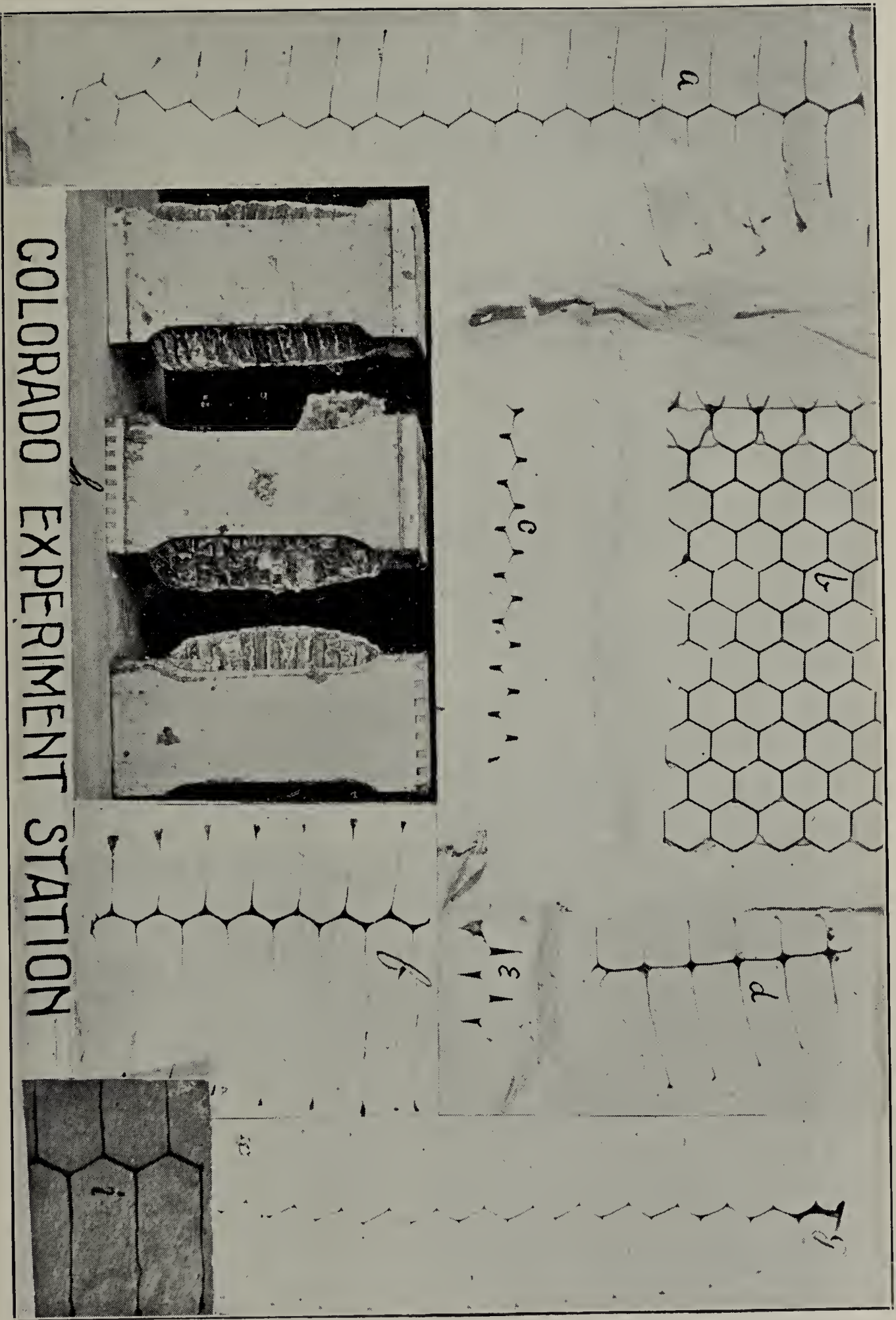


PLATE 5.



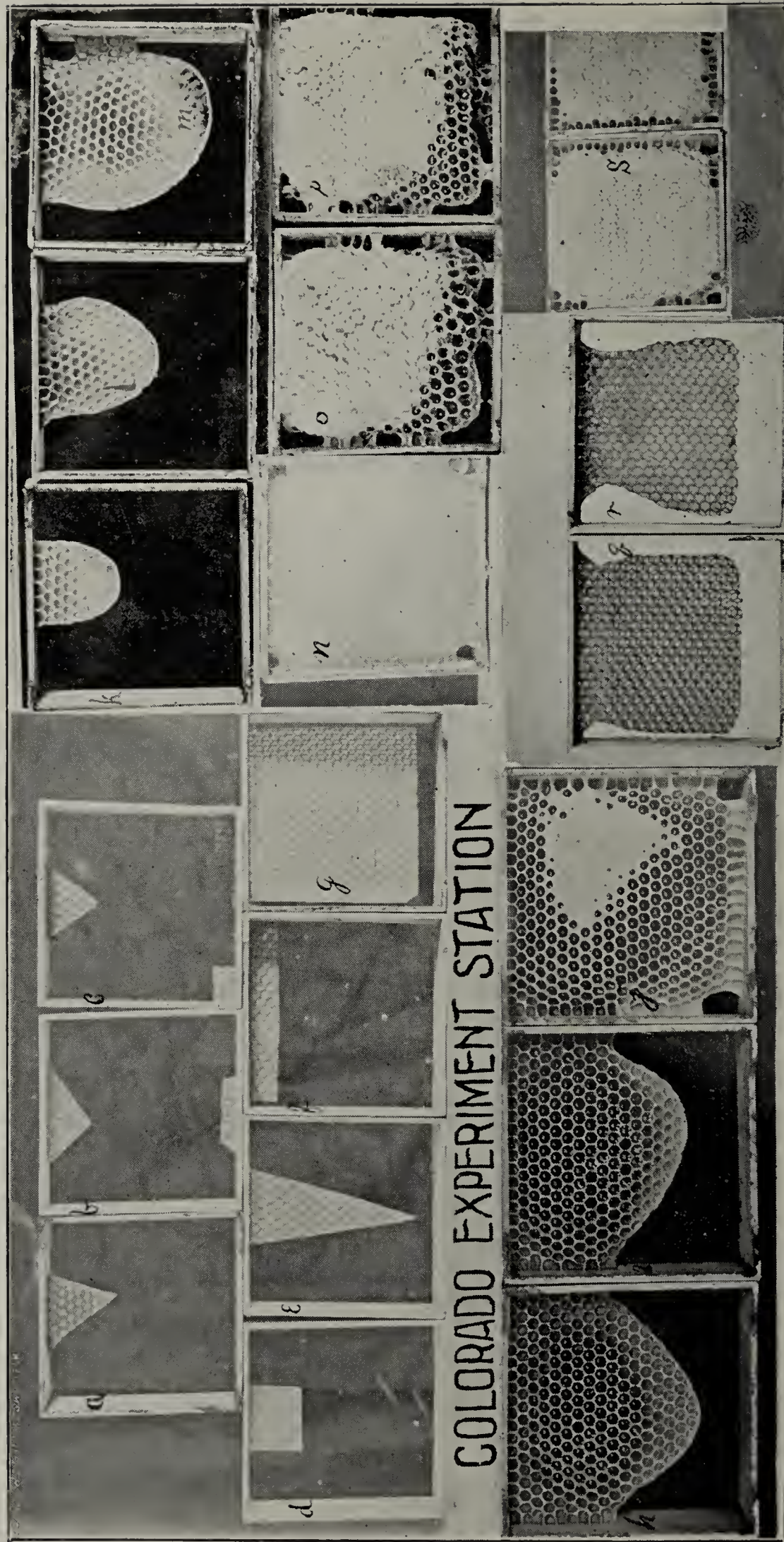


PLATE 6.



*Desk*

Bulletin 55.

1901

# The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

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## FORESTS AND SNOW

—BY—

L. G. CARPENTER.

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Published by the Experiment Station,  
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# THE AGRICULTURAL EXPERIMENT STATION

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\* Died December 9, 1900.



# FORESTS AND SNOW

BY L. G. CARPENTER.

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The intimate connection between the melting snow banks of the mountains and the agricultural prosperity of Colorado is too evident to those acquainted with the conditions of the State to need discussion, for most of the water which carries fertility to the fields and farms comes from the white-capped mountains; but even among those most interested in the agriculture of the State there have been some who have had a question as to the extent to which the forests were useful. Some have even advocated their destruction, under the supposition that the water supply would be increased.

While it is not thought by the writer that the forests materially affect the rainfall in our Colorado mountains, their influence as a protecting cover for the snow and in saving it from premature melting and the effect of winds, which increase the evaporation, is an important function. Without intending to enter upon a discussion of the question at this time, this bulletin is more especially intended to bring out some of the relations of the forests to our water supply, which have become evident in our study of one of the typical irrigation streams, and also to present some of them pictorially, in such form as to help the reader draw conclusions for himself.

For some years attempts have been made to obtain photographs which would show certain conditions, but as visits to the localities in question were usually made for other purposes, the trips were too late to be at the best time to examine the effect of the forests. It was found that it would be necessary to go earlier in order to obtain views desired, and to make trips for that special purpose. Hence, when the heavy snowfall of 1899 gave promise of remaining late enough in the summer to permit visits to the regions without interference with other work, advantage was taken of it. Correspondence had been opened with mountain friends, who with long acquaintance with mountain conditions had had unusual chances for observation. They were asked to let me know when the snow cover had so melted that the ground appeared in places, and also the places where green timber and bare spots were near together, so that the conditions could be readily compared. A portable dark-room was prepared for developing in the field. Reports that the conditions were favorable were received from three correspondents on the same day. The snow fields were melting so fast that only one section could be visited while the conditions were favorable, and this was near

the headwaters of the Cache a la Poudre. Two places, some twenty mile apart, were visited. One on the divide between the Poudre River and Estes Park, and the other on the headwaters of the Laramie River. The former was visited under the guidance of Mr. John Zimmerman, who is a native of Switzerland, and who has lived in the high elevations of Colorado for nearly twenty years; the latter, under the direction of Mr. John McNabb, who has also had a long and intimate acquaintance with high elevations. The results are shown in the plates, which speak for the photographic skill and successful carrying out of instructions by Mr. J. D. Stannard, then assistant in the Department of Engineering. It is believed that no more striking series of photographs on this subject has been brought together. They enable a comparison of the conditions to be made by the reader and repay examination and thoughtful consideration in connection with the charts.

We hoped to obtain an additional series of photographs during the subsequent winter, but the character of the snowfall was unfavorable for this purpose.

A general description of the condition of the streams, as connected with the melting of the snows, is desirable as a basis for the explanation of the views.

#### CHARACTER OF THE STREAMS.

Colorado is moderately supplied with rain, the annual precipitation averaging about fourteen inches. In the mountain areas, the amount varies with the elevation and topographical conditions, but the increase with elevation is not marked until the extremely high elevations are reached. In these places observations are under exceptional conditions, and too few in number to form a safe guide. On the eastern slope of the mountains, the precipitation is mostly due to the easterly winds brought in by the passage of an area of low barometer to the south. The air is forced up by the mountain ranges, and cooled by the elevation enough to cause condensation and precipitation. Sometimes there are extremely heavy local showers, often called cloudbursts. Much of the precipitation at the higher elevations, even in the summer months, is in the form of snow. June, July and August are practically the only months in the year when rain falls at or above timber line. Snowfalls are not uncommon down to an elevation of 6,000 feet, even in May.

The rain runs off quickly and may immediately influence the streams. The snow remains until it is melted or evaporates. Its effect is gradual, and may thus last for some time. Most of the winter precipitation in the mountains remains on the ground in the form of snow until spring. A portion, sometimes not inconsiderable, evaporates, especially when the snow is porous or soft. It may then be seen to visibly decrease. Heavy winds which blow the snow about increase this loss. Some of the mountain observers say, "The wind just naturally wears it out."

In the case of land denuded of timber the surface is generally hard, and the water runs off rather than penetrates. In the forest areas the soil is looser, more porous and absorbent, and takes up water freely. In such areas springs, or springy soil, are more common, while they are



rarely found in tracts burned over or denuded of timber. It is the water from these springs which maintains the flow of the rivers from September to April. Their decrease is cause for alarm. Within the past few years the Poudre at one time fell to less than forty cubic feet per second. April and May are the months of heaviest rainfall; most of the continued storms occur during these months. Yet, our river records, now carried on for nearly twenty years, show that these rains have comparatively little effect. A rise in the river due to a storm is distinguishable from one due to melting snow, as may be seen from the diagrams. The snows show a daily tide, usually at the same hour. The rises due to storms are irregular in time and character. An unexpected effect is that rains in the mountains usually decrease the amount of water. The cloudiness associated with the storms prevents more thawing than the rain supplies.

If the area covered by snow has been extensive and extends to a relatively low elevation, with the coming of warm weather the snow melts soonest on the low areas. As a rule these are less protected from the rays of the sun. Melting proceeds, even to considerable elevations, in the direct rays of the sun, though freezing may be going on at the same time in the shade, as on the north side of the ridges. A forest cover protects from the direct rays of the sun just as the ridges do.

In the middle of the summer, snow is to be found at moderate elevations only in the forests or under ridges where sheltered from the direct rays of the sun. As melting proceeds the tributaries are swollen, and the main streams increase in volume, their maximum being reached long before the greatest heat of summer. Though the melting is faster, the snow areas are so much less that the aggregate is reduced, hence, the stream decreases.

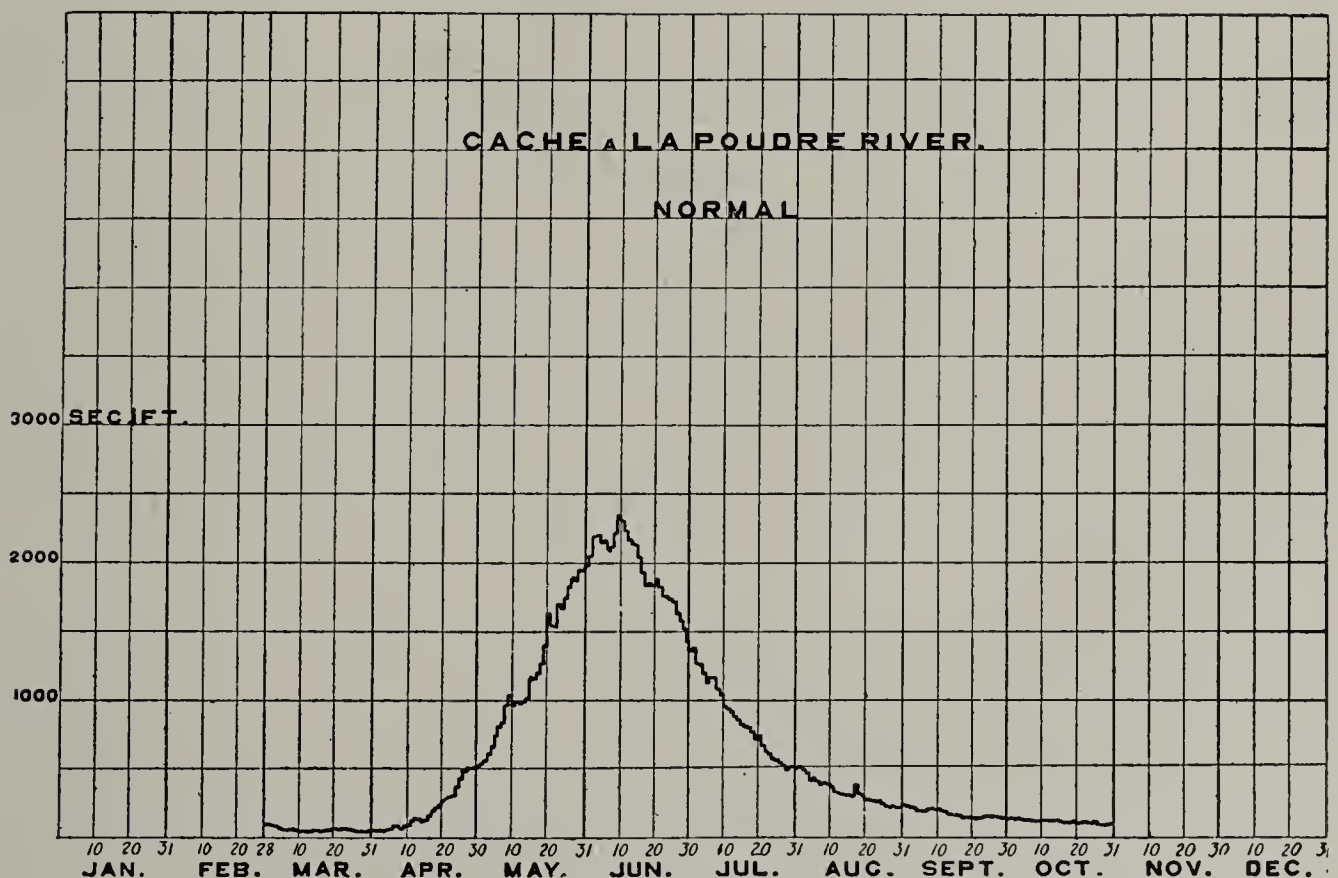


Figure 1.

A typical stream is shown in Fig. 1. This represents the flow of the Cache a la Poudre, on which a longer series of records are available than on any other of the Western streams. The diagram is from nearly twenty years' record of automatic instruments.

The stream is low in fall and winter, when the supply is largely from springs. It rises in April with the rains or melting snows, and more rapidly as the sun and increasing temperature acts on the snow fields.

The rate of rise depends on the area which is covered with snow; on the temperature of night and day; on the dryness of the air, as affecting evaporation; the area of the forest! and the character of the snow, whether it be new and soft or old and hard.

#### DAILY EFFECT OF THE SUN ON THE MELTING.

A daily rise and fall takes place and is more marked as the river rises. This is shown by the various diagrams. Fig. 2 is a fac-simile of the diagram taken from the instrument during the week from June

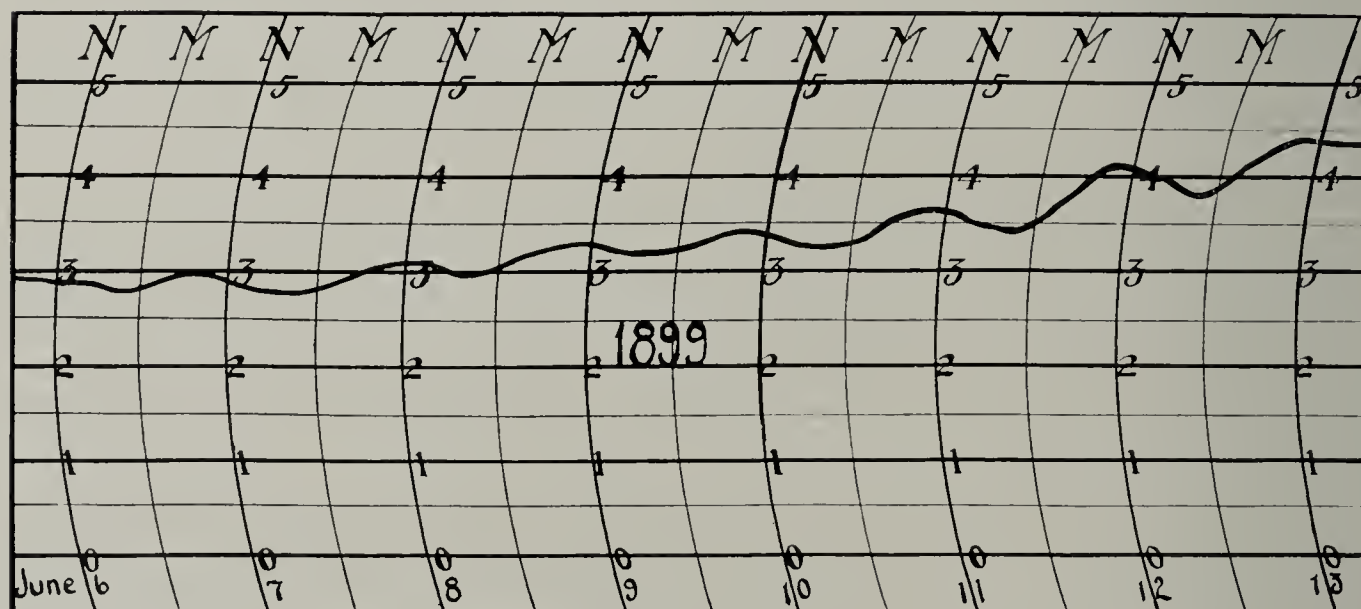


Figure 2.

6-13, 1899. The days are shown at the bottom of the diagram, the gage depths at the left. "N" indicates the noon hour, "M" midnight. The crests of the rises are seen to be twenty-four hours apart. The high water occurs from 4 to 6 a. m. at the point where our instrument is placed, and the low water about 8 p. m. This hour depends on the distance to the snow fields. An examination shows that the extreme fluctuation on June 20-21 was nearly a foot, less on the other days.

When we consider the quantity of water, instead of the depths, this fluctuation appears of more importance. Fig. 4 represents the quantity of water for the same week as shown in Fig. 2. The scale at the left gives the quantities in cubic feet per second. While on the evening of June 20 there was less than 3,000 cubic feet per second, before morning it had become 4,700 cubic feet, falling back to about 3,300 cubic feet during the day, and rising again to 3,900 feet during the night. This diagram is typical of the fluctuation in sunny weather



during high water. The change is clearly connected with the diurnal effect of the sun. It is seen in the other diagrams, but almost disappears in cloudy weather.

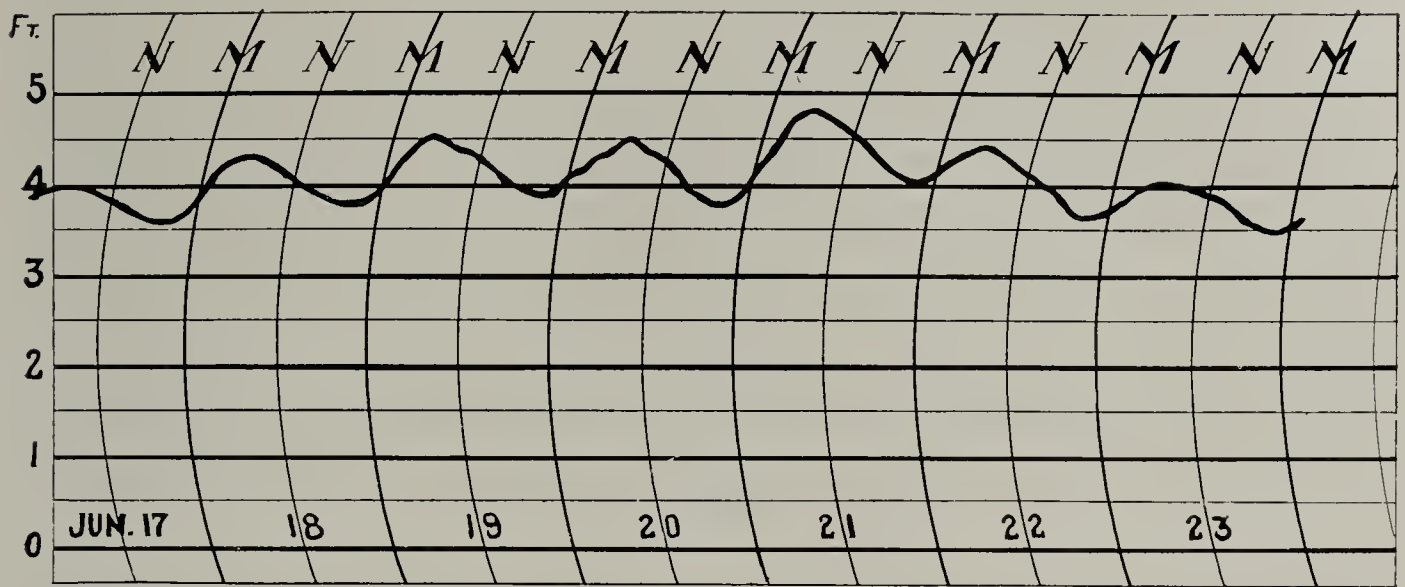


Figure 3.

While the temperature has a marked influence in determining the general stage of the river, the direct action of the sun as shown by the diagrams is still more marked, as it causes these fluctuations. Anything

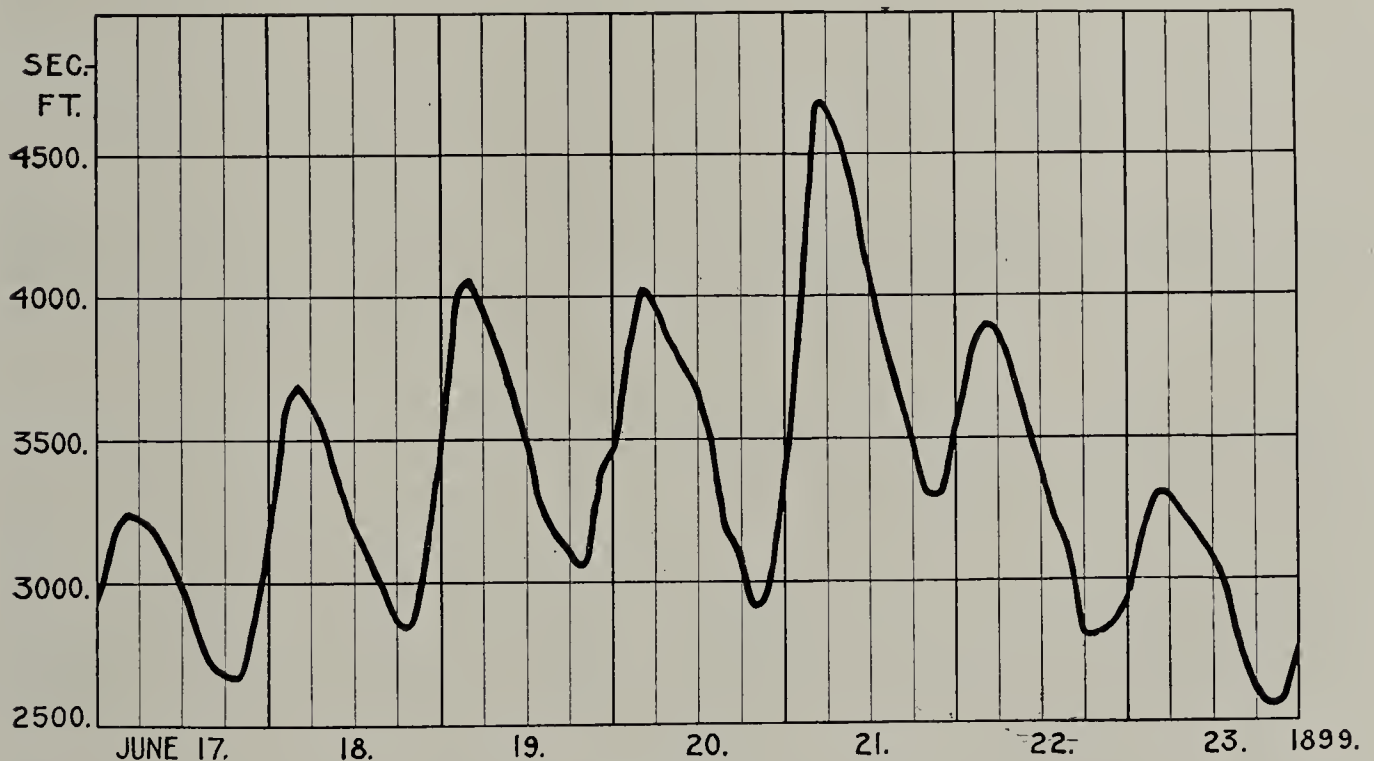


Figure 4.

which serves as a protection from the sun, whether forests, ridges, boulders or clouds, lessens the melting and tends to decrease these tides. This explains the paradoxical fact that a general rain in the mountains often lessens the amount of water in the river.

This effect is illustrated by Fig. 5, which shows the record of a rainy week in 1898. On June 1 the diurnal fluctuation was slight, on

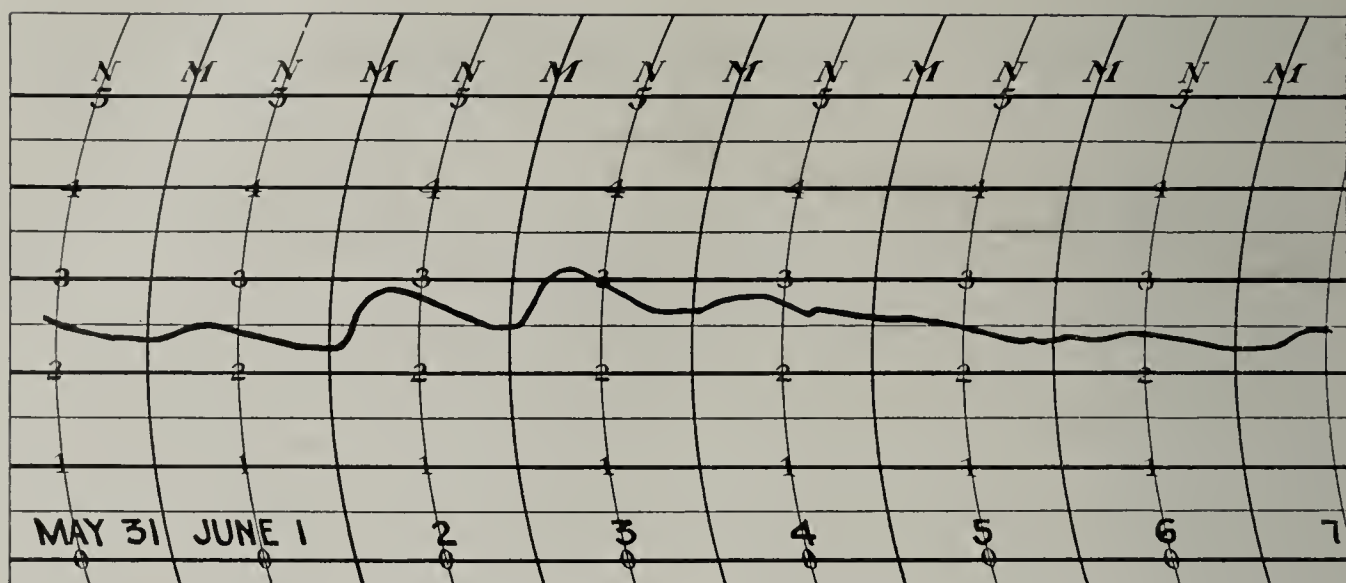


Figure 5.

June 2 it was more marked, and still more so on June 3. For the rest of the week it was scarcely noticeable. The days of June 1 and 2 were sunny, the two following days were rainy, and the rest of the week cloudy. On the night of June 3-4, 1.12 inches of rain fell at the Station, an unusually heavy rainfall, yet the river was lower after this rain than before. The clouds protected the snow from the sun, and this was of more effect than the exceptional rain.

Another record illustrating the effect of a general cloudiness, is for the last week in May, 1897, shown in Fig. 6. The flow for this week was

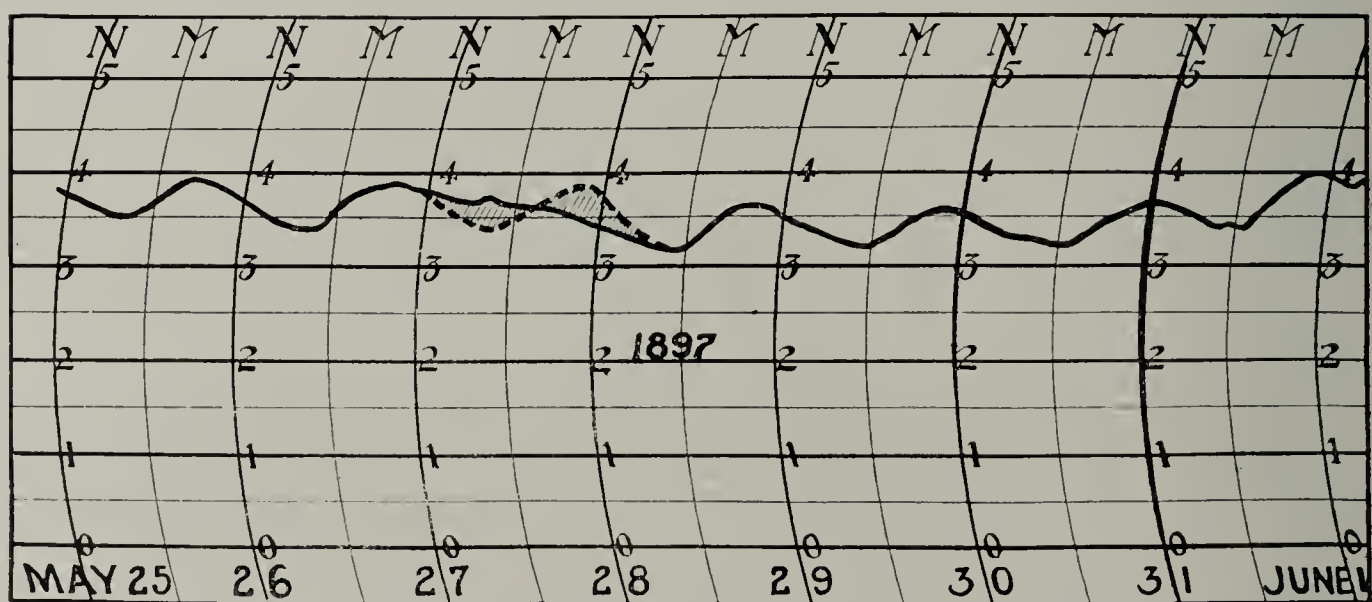


Figure 6.

normal, except on the 28th, when the river lacked the fluctuation evident on the other days. This was due to the character of June 27. It was cloudy and rainy all day at Fort Collins, and also over the whole watershed. The precipitation at the Station amounted to .28 in. There were hard showers near the river, as shown by the slight rise on the afternoon of the 27th. At Westlake, at an elevation of about 8,500 feet and about the middle of the watershed, the precipitation was .80 in. Notwithstanding this heavy rainfall the river shows a steady decrease. The dot-



ted line shows the probable course of the fluctuation, as judged from the records of co-operating observers, had there been no storm and the weather remained clear.

The different effect of a local shower on the river is shown in Fig. 7. Two local storms are in evidence on this record; one on the afternoon of May 18, and the other beginning to show on the afternoon of May 20, with a marked rise during the night.

The storm of May 18 was a sudden violent shower over a small area. As it was near the river, the effect was very marked. The rain-gauge at the Station recorded only .03 in. A shower of .20 in. on May 19 does not show; but there was a storm on the night of the 19th and extending throughout much of the forenoon of the 20th, amounting to 1.28 inches. This was heavy in the mountains also, especially at the lower elevations. The effect is seen in that the river continued to rise on the morning of the 20th, instead of falling. The sudden rise about midnight was due to the access of the flood from one of the important tributaries.

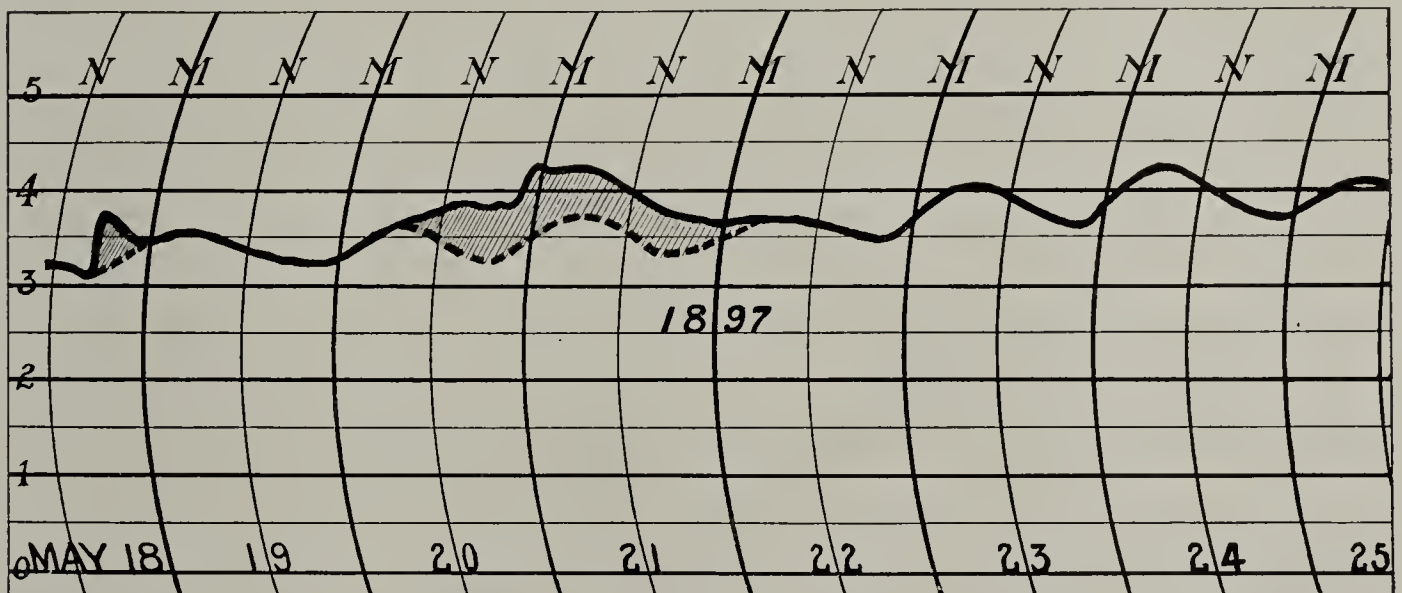


Figure 7.

The dotted line shows the probable fluctuation of the stream if there had been no storms. Neither of the storms extended to the higher elevations and did not cause general cloudiness, and the general course of the river was but little affected.

As snow is most evident on the high peaks, undue importance is attached to high elevations. The run-off from the forest fringes below timber line is of far more importance. The precipitation at the high elevations is not much, if any, more than at lower elevations. The rainfall on Pike's Peak, standing as it does on the edge of the Plains, cannot be considered representative of the other high elevations, and is undoubtedly much greater than that on other peaks equally as high. Even if a great amount of precipitation falls on the top, it is confined to a small area of relatively little importance. Thus, for instance, I have had occasion to examine the watershed tributary to the Rio Grande. While this has an area of 4,611 square miles above 8,000 feet elevation, there is less than 200 square miles of it above 12,000 feet, although this watershed has a large number of the highest peaks in the State.

In this case, over 90 per cent of the watershed is below timber line and above 8,000 feet.

That the forests in the mountains increase the amount of precipitation does not seem probable, whatever their effect when on the plains or lands of low elevation may be. The precipitation in the mountains is mostly due to the cooling from expansion, caused by the air being forced upward by the mountains. The effect of the forests would be so small compared with the mountains that it does not seem possible that they would increase the amount of rainfall. It, however, is not impossible that in the maintenance of moist conditions, influence on the currents of air, and the protection of slopes from the burning rays of the sun, there may be an effect even on the amount and distribution of the rainfall. Nevertheless, they influence the river floods, and protect the snows from melting and the action of the winds. As a protection from floods, they form a feature which the agricultural interests of the State should jealously protect.



## CONCLUSIONS.

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1. The mountain streams in the early irrigation season are largely supplied by melting snow.

2. There is a marked diurnal fluctuation, greater with high water than with low, due to the daily variation in the rate of melting.

3. The stream at high water may be one-half greater than at low water on the same day.

4. Cloudy weather in the mountains, protecting the snow from the radiation of the sun, causes the fluctuation to disappear and the flow to decrease.

5. This decrease is so great that the cloudiness associated with continued rain usually more than counterbalances the gain from the rain.

6. The loss of snow by evaporation is considerable, especially when exposed to winds.

7. Snow remains in the timber and in protected spots much longer than where exposed.

8. This is due not so much to drifting as to shelter from the radiation afforded by the forest cover.

9. Hence, the greater amount of forest cover the less violent the daily fluctuation, the more uniform the flow throughout the day and throughout the season, and the later the stream maintains its flow.

10. The loss of the forest cover means more violent fluctuation during the day, greater difficulty in regulating the headgates and keeping a uniform flow in ditches and hence an additional difficulty in the economic distribution of water. Also the water runs off sooner, hence the streams drop earlier in the summer and on account of the lessening of the springs, the smaller is the water flow.

11. The preservation of the forest is an absolute necessity for the interest of irrigated agriculture.

## PLATES.

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**PLATE 1.**—11:30 a. m., June 21, 1899. Elevation about 9,600 feet. Looking southwest into dead timber. Medicine Bow Range in the distance.

**PLATE 2.**—11:40 a. m., June 21, 1899. Looking northeast into open white pine timber. Ground sloping gently to the northwest. Snow drifts from three to five feet deep.

**PLATE 3.**—3 p. m., June 21, 1899. Looking east. Plates 9, 10, 11 and 12 were taken near here. Mr. Zimmerman is shown on the drift.

**PLATE 4.**—11:00 a. m., June 21, 1899. Looking northwest, showing Mr. Zimmerman behind drift. Slopes to the northwest. Drifts hard. Elevation about 9,600 feet. Open white pine timber. Nos. 5 and 6 taken from this point.

**PLATE 5.**—11:00 a. m., June 21, 1899. Looking north from same point as No. 4.

**PLATE 6.**—11:20 a. m., June 21, 1899. Looking southwest into dead timber.

**PLATE 7.**—10:30 a. m., June 21, 1899. Snow in the open white pine timber. Slopes to the north. Nearest drift, 60 feet long, 48 feet deep, 15 feet wide. Snow granulated. Elevation about 9,600 feet. Looking southwest.

**PLATE 8.**—4:05 p. m., June 19, 1899. Near No. 13. Snowdrift in the distant green timber.

**PLATE 9.**—12 m., June 21, 1899. Looking southwest. Bare slope. Elevation about 9,600 feet.

**PLATE 10.**—1:30 p. m., June 21, 1899. Drift 10 feet deep in green timber. Usually no snow here after June 1st. About 200 yards in timber from points where Plates 1 and 2 were taken.

**PLATE 11.**—2:45 p. m., June 21, 1899. Snow drift in green timber. From same point as Plate 12. Looking east. Ground slopes to east. Drifts about 12 feet deep, solid. Same drifts as in plates. Elevation about 9,000 feet. Four miles back of Zimmerman's.

**PLATE 12.**—2:40 p. m., June 21, 1899. From the same place as Plate 11. Looking southwest through dead timber. Mount Cameron in the distance.

**PLATE 13.**—8:50 a. m., June 24, 1899. Looking north. Elevation about 10,000 feet. Headwaters of the Laramie River. Ground slopes to the south.

**PLATE 14.**—9:45 a. m., June 24, 1899. Looking southwest. Near No. 13. Spruce and balsam.

**PLATES 15, 16, 17 and 18.**—June 24, 1899. From same point. Elevation about 9,800 feet. These views overlap, and may unite into one view. **No. 15,** 9:45 a. m. In dead timber, looking west. On south slope. **No. 16,** 10 a. m. Looking northwest into green timber. **No. 17,** 10:15 a. m. Looking north at south slope, showing snow in green timber. **No. 18.** 10:15 a. m. Looking northeast. Snow in green timber, bare ground in dead timber. Showing edge of snow between dead and green timber.

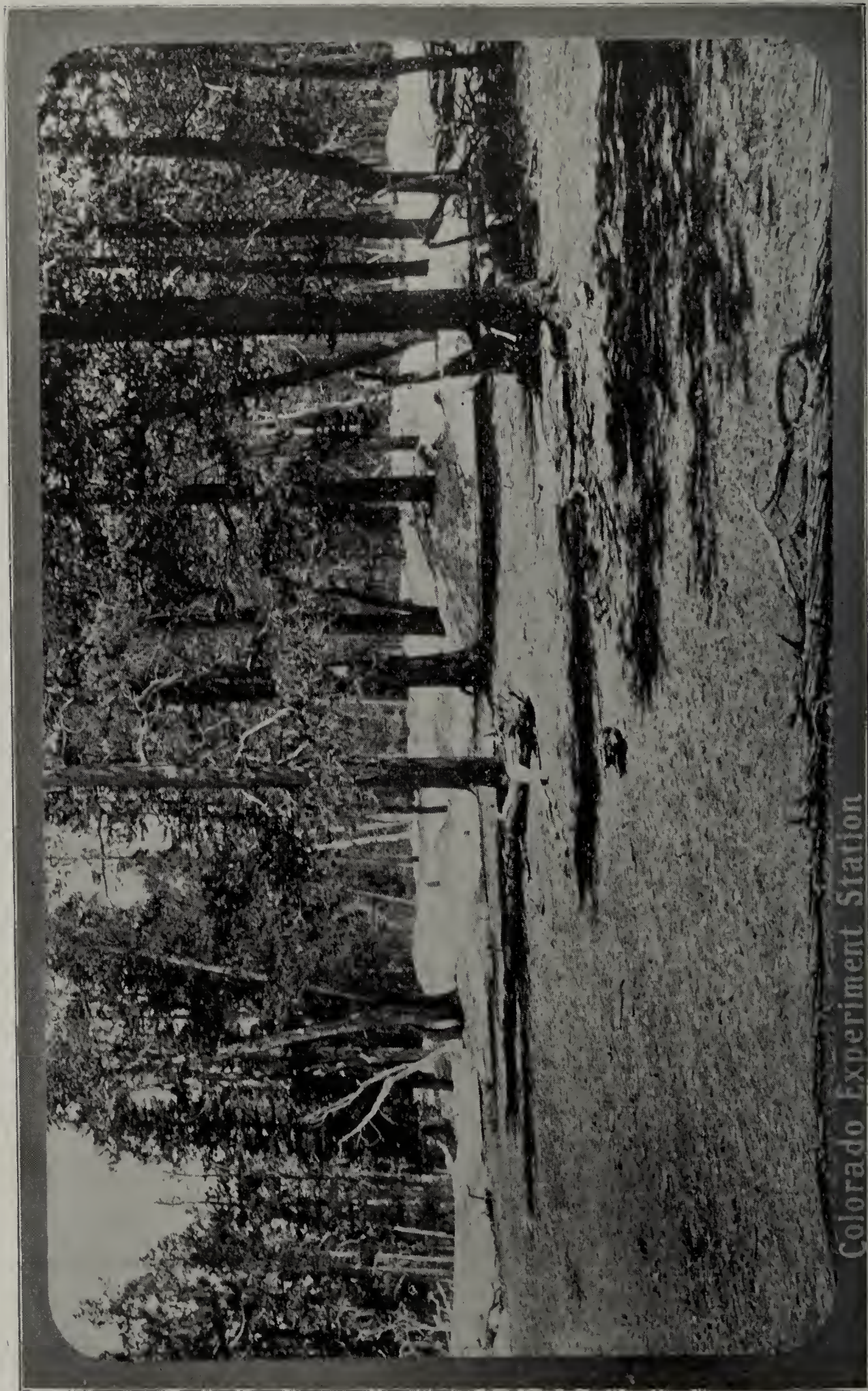




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PLATE 1. From the same spot as Plate 2. Same date. Looking northwest.

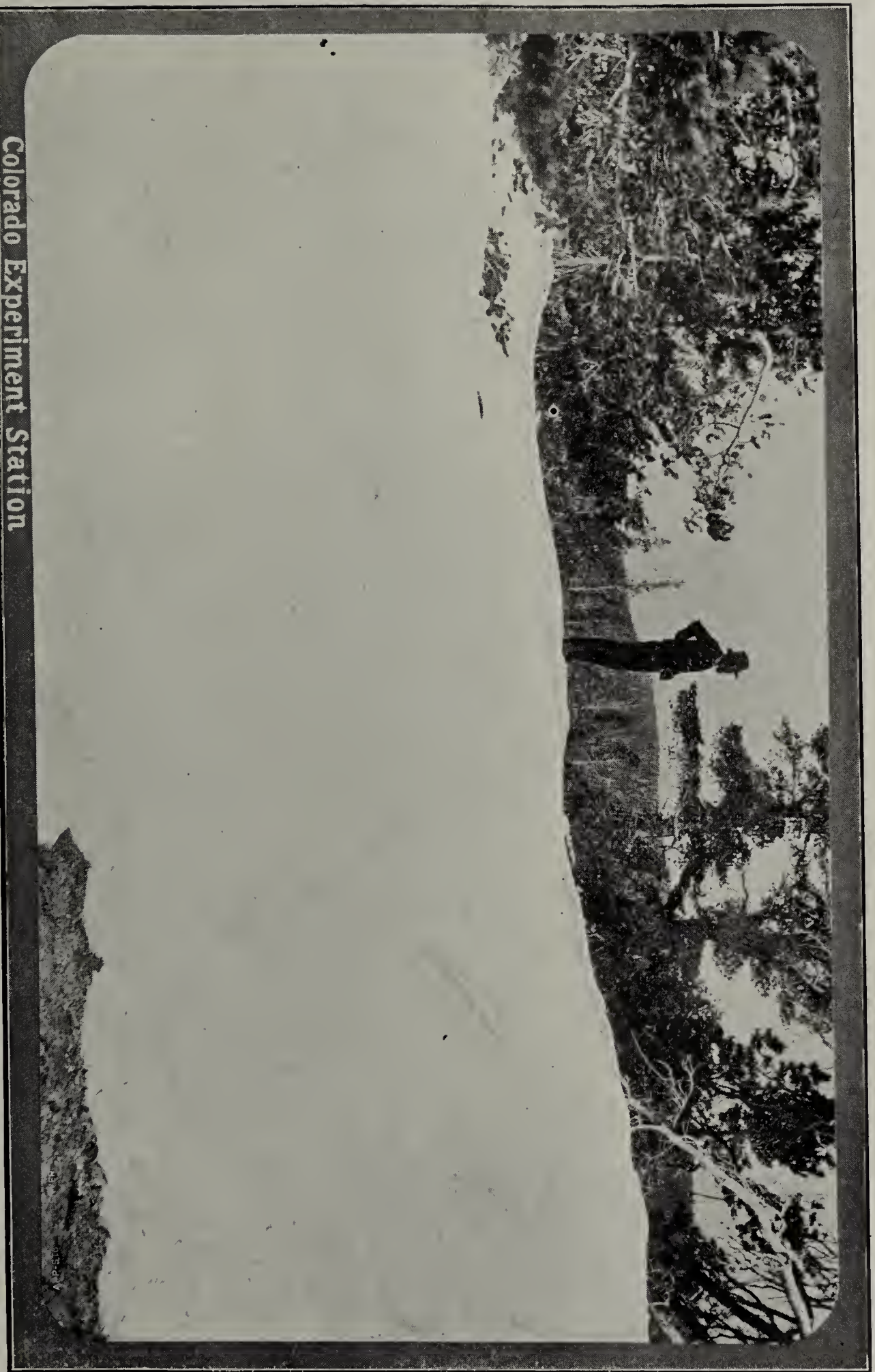




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PLATE 2. Looking northeast into green timber. June 21, 1899.





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PLATE 3. Snow drift. June 21, 1899.





PLATE 6. Looking into dead timber.



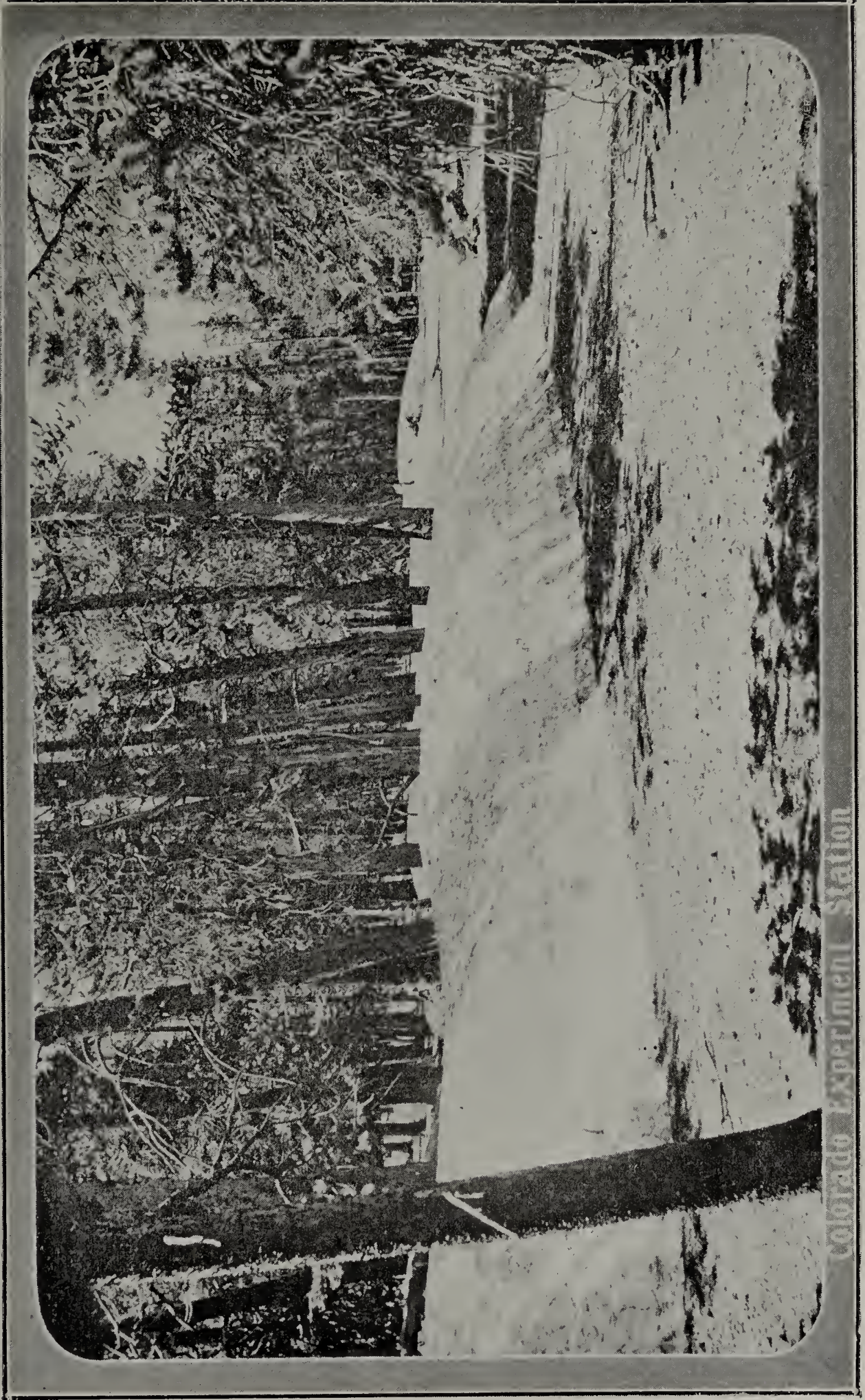


PLATE 7. Snow-drifts in pine timber.





PLATE 10. Drift in green timber.





PLATE 11. Looking east from same place as Plate 10.



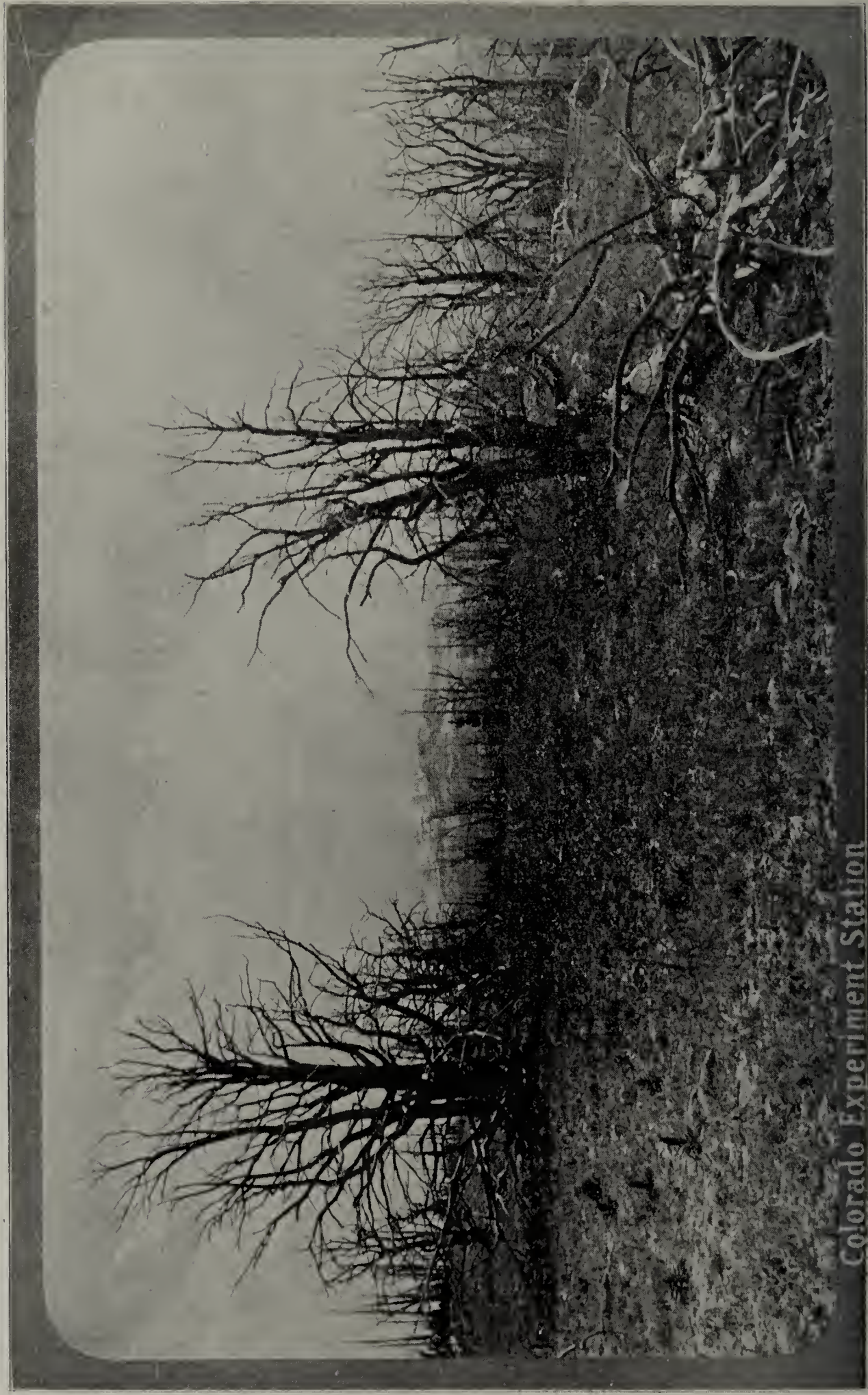
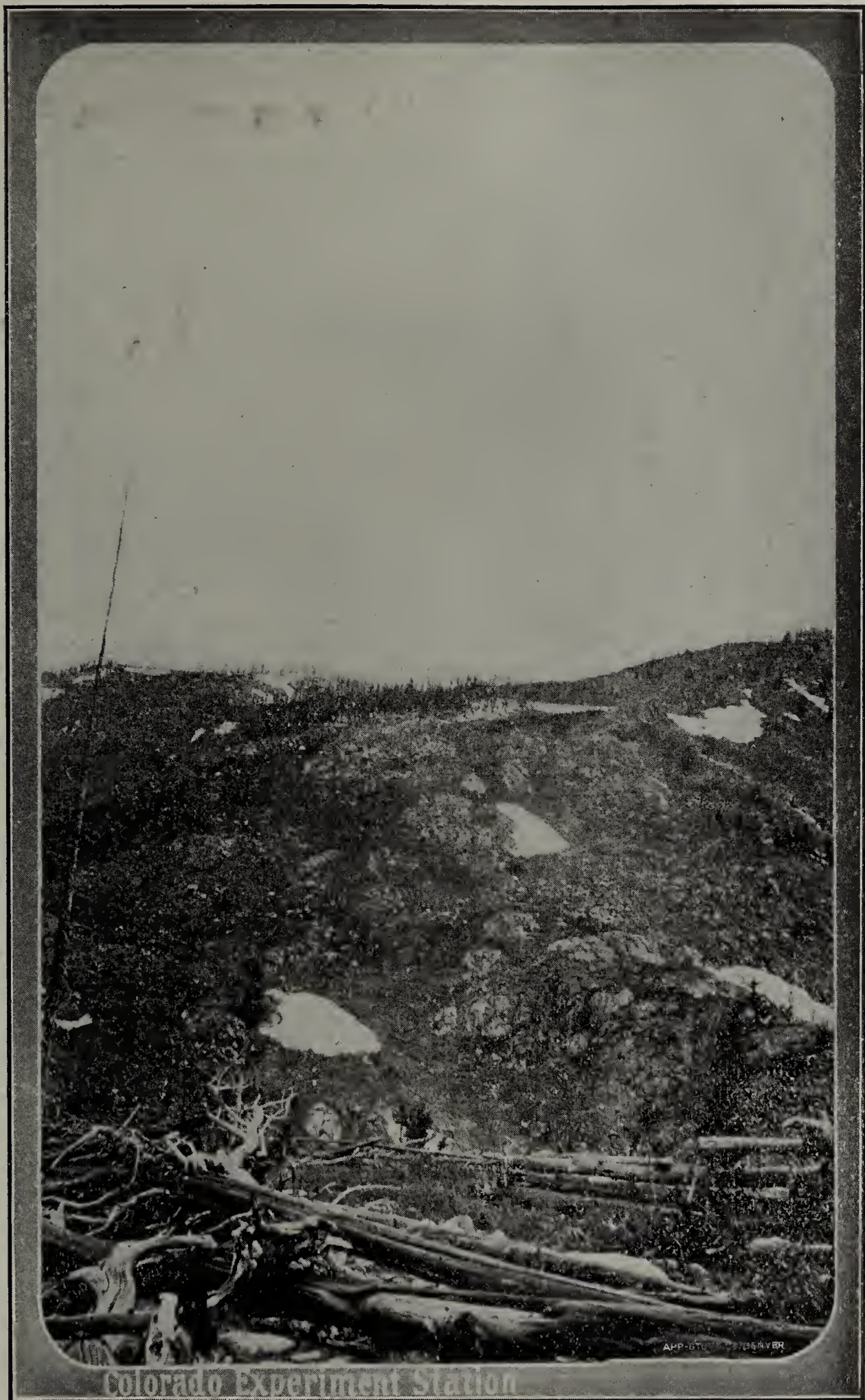


PLATE 12. Looking southwest into dead timber.





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PLATE 13. Snow in sheltered spots.

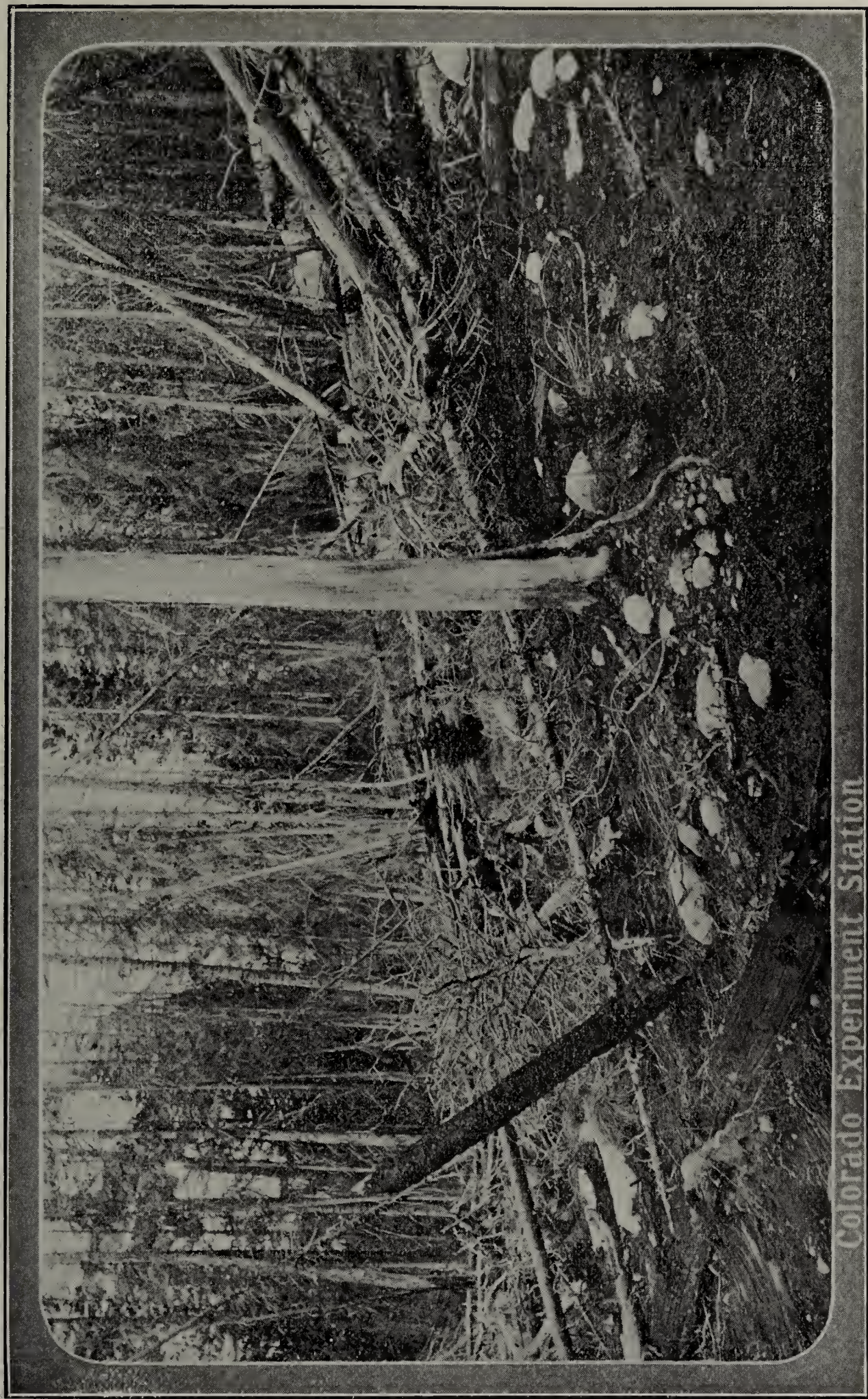




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PLATE 14. Snow in sheltered ravine.





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PLATE 15. Plates 16, 17 and 18 from same point. Looking west.



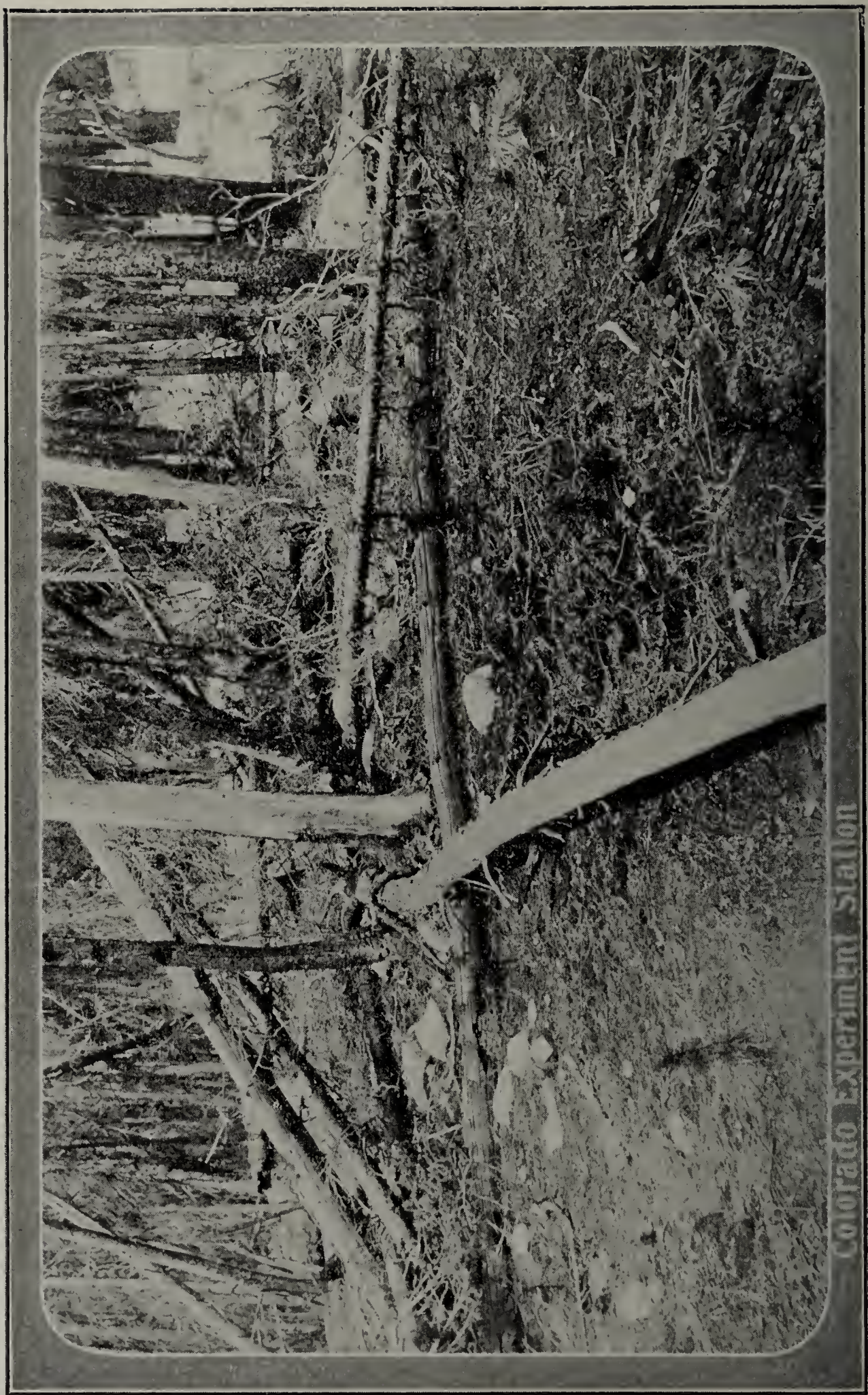


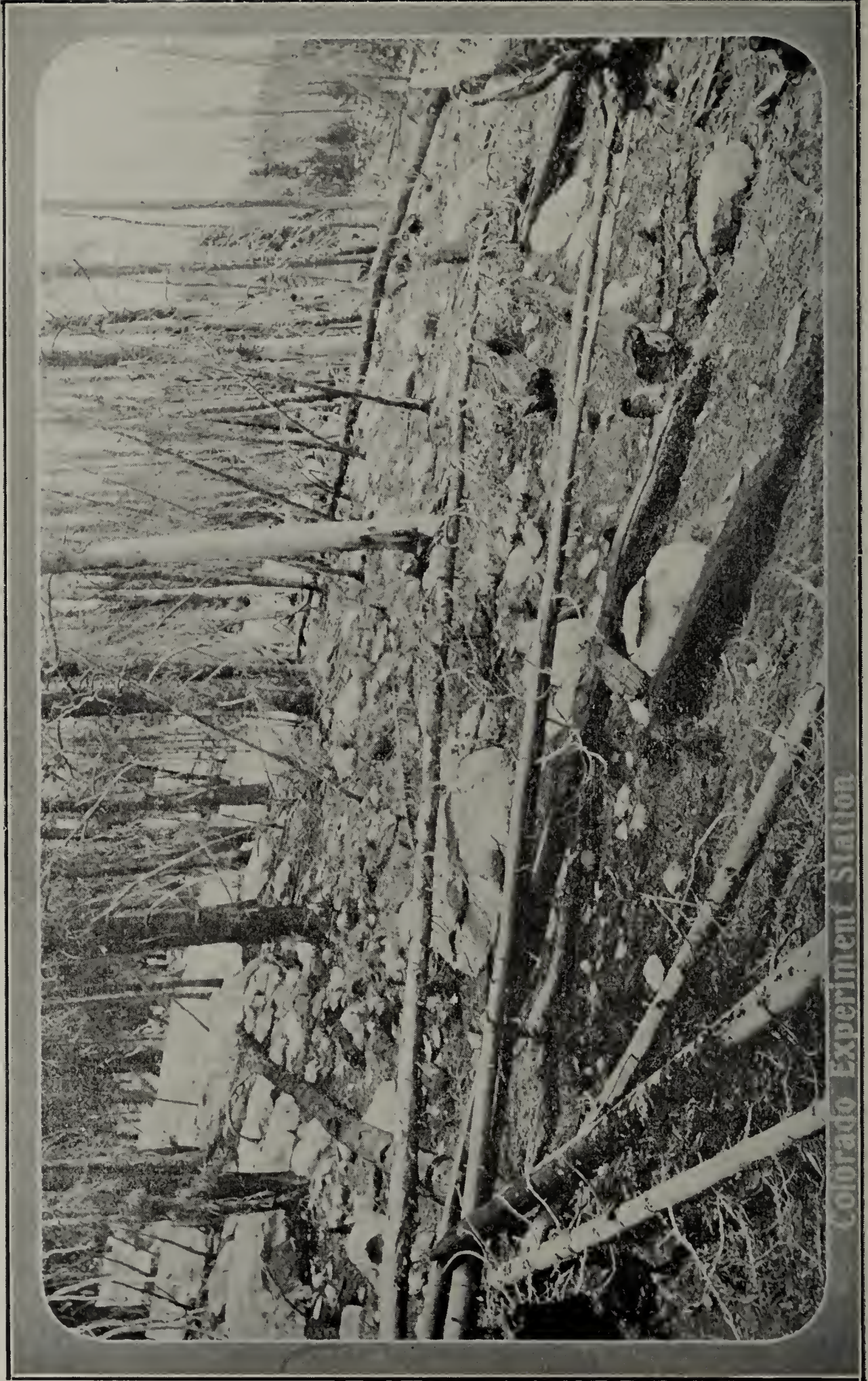
PLATE 16. Looking northwest.





PLATE 17. Snow in green timber looking north.





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PLATE 18. Looking northeast,



**Bulletin 56.**

(Technical Series No. 5.)

**May, 1900.**

# The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

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THE

# BIRDS OF COLORADO

A Second Appendix to Bulletin  
No. 37

—BY—

W. W. COOKE

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PUBLISHED BY THE EXPERIMENT STATION  
Fort Collins, Colorado.  
1900.

# The Agricultural Experiment Station

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**FURTHER NOTES**  
**ON**  
**THE BIRDS OF COLORADO.**

---

**BY W. W. COOKE.**

Since the publication in March, 1898, of the notes on Colorado birds that had been gathered the previous year, many additional notes have been secured. The largest number from any one source have come from a thorough study of the fine collection of Mr. Edwin Carter at Breckenridge. This collection represents the work of Mr. Carter for more than thirty years. Much of the material was gathered in the immediate vicinity of Breckenridge, and the rest in Middle Park and South Park. Breckenridge is at an altitude of 9,500 feet, while Middle and South Parks are from 7,500 to 8,500, so that Mr. Carter's collection is especially valuable as showing the bird life of the mountains and mountain parks. Breckenridge is on the western slope of the main range, and this collection furnishes several new records for the Pacific side of the mountains as well as a higher range than before known for more than thirty species. The Carter collection contains 184 species of birds, of which 127 are known to breed in Middle and South Parks. Mr. Carter has also taken 16 species that are not now in the collection. The collection adds two new birds to the state, *Ammodramus leconteii* and *Falco sparverius deserticolus*, and one new breeding record, *Wilsonia pusilla pileolata*.

Much space is given to notes from this collection, because the recent death of Mr. Carter makes the collection complete so far as his work is concerned. No catalogue or summary of this collection has ever been published. The present writer made three visits to Breckenridge, and has studied every bird in the collection at least twice. The last visit was but a few days before Mr. Carter left home on that last trip from which he was not to return alive. On this visit a complete investigation was made of all Mr. Carter's records of birds he had taken that are not now in

the collection. This bulletin therefore presents the full work of Mr. Carter with reference to Colorado ornithology. Many of the notes from his collection add nothing new to our knowledge of the birds of the state, but are entered in order to make a complete catalogue of the species represented in the collection.

Most of the rest of the new notes come from the further investigations of Mr. C. E. Aiken, who has spent a great deal of time the past two years in collecting and studying the birds of the "Divide" and the plains east of Colorado Springs. From his own collecting he has added five birds to the Colorado list, and of two more he has obtained the records from other persons. One of the excursions of Mr. Aiken deserves special mention as showing the possibilities of Colorado ornithology. The days from May 19-27, 1899, he spent in the vicinity of Limon, about a hundred miles out on the plains east of Colorado Springs. A poor place for birds one would think, and yet while there he encountered what seemed to be a flight of eastern birds that had wandered from their usual course and strayed several hundred miles to the westward, and mingled with them some distinctively western species scarcely to be expected east of the mountains. The Red-bellied Woodpecker, Tennessee Warbler, Least Flycatcher, Red-bellied Nuthatch, Bobolink and Scarlet Tanager were rare visitants from the east found there, and in addition he took the Connecticut Warbler and the Canadian Warbler, both being the first records for Colorado.

In contradistinction to this highly successful trip, may be noted one taken by the present writer, which also shows the peculiar distribution of bird life in Colorado. About the middle of May he went from Fort Collins to Grand Junction. The latter place is about a hundred and fifty miles further south and five hundred feet lower than Fort Collins. Vegetation was at least two weeks in advance of the more northern location, but bird migration was apparently in just the same stage; being another instance of what is probably a general rule, that migration on a western slope is later than on an eastern. More surprising than this, however, was the character of the birds seen. Grand Junction is three hundred miles west of Fort Collins, on the Pacific slope and on the Grand river, that one would expect to find a natural highway for birds from the west and south. The country was quite carefully explored for twenty miles along the Grand and Gunnison rivers, and in all somewhat over forty different species of birds were identified. They were all common birds of the eastern slope, occurring at Fort Collins, except the Raven and the California Quail. The former occurs over all of



western Colorado, while the latter has been introduced and has become exceedingly abundant. Out among the greasewoods, where greasewood is about the only vegetation that can grow, these Quail vie with the lizards as to which shall be the most common animal life present. In the whole trip not a distinctively southern or western species was observed, nor is there one in the list of sixty-one species of birds seen there by Miss Myra Eggleston during several years residence. The valley of the San Juan river serves as a great highway for southwestern forms into southwestern Colorado; and many extend along the Rio Grande into south central Colorado on the Atlantic slope, but apparently there is some conformation of land or condition of climate that keeps these forms away from west central Colorado.

The present bulletin is paged in continuation of bulletins Nos. 37 and 44, and references are to the pages of these bulletins. On page 3 the total number of species and varieties known to occur in Colorado should be changed to 387, of which 243 are known to breed. Thus in the three years since the Colorado list was published, 27 additions have been made and 15 more species ascertained to breed in the state. There is good reason to believe that the list, even now, is far from complete. A single fact will show how great are the future probabilities. In a small collection of beautifully mounted birds at Cheyenne, Wyoming, prepared by Mr. Frank Bond, are six species of birds taken by him at Cheyenne, less than ten miles from the Colorado line, that have not yet been found in this state. These species are *Sterna hirundo*, *Pelecanus fuscus*, *Crymophilus fulicarius*, *Ægialitis meloda circumcincta*, *Anthus spragueii* and *Cistothorus stellaris*, and there is every reason to believe that each of these will eventually be added to the Colorado list.

## CLASSIFICATION OF COLORADO BIRDS.

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Changes to be made, including those already made on page 128 and pages 148-150.

Page 8. 1. **Residents:** Add

Callipepla squamata.  
Tympanuchus americanus.  
Phasianus torquatus.  
Falco sparverius deserticolus.  
Syrnium nebulosum.  
Coccothraustes vespertinus montanus.

Page 9. 2. **Winter visitants.** Omit

Coccothraustes vespertinus montanus.

Page 10. 4. **Species that have been taken in Colorado in winter, either as rare or accidental visitors.** Add

Gavia arctica.  
Larus philadelphia.  
Somateria dresseri.  
Nyctala tengmalmi richardsoni.  
Acanthis linaria rostrata.  
Junco montanus.

Page 11. B. *Species that breed on the plains, but only to the foothills of the mountains.* Add

Philohela minor.  
Callipepla squamata.  
Tympanuchus americanus.



Phasianus torquatus.  
 Syrnum nebulosum.  
 Phalænoptilus nuttallii nitidus.  
 Zamelodia ludoviciana.  
 Seiurus aurocapillus.  
 Harporhynchus bendirei.

Page 12. *C. Species that breed in the mountains or mountain parks and not on the plains. Add*

Falco sparverius deserticolus.  
 Coccythraustes vespertinus montanus.  
 Wilsonia pusilla pileolata.

*D. Species that breed principally in the mountains. Add*

Empidonax hammondi.

Page 13. *E. Species that breed regularly only in Southern Colorado. Add*

Plegadis guarauna.  
 Callipepla squamata.

Page 13. **6. Species taken in the State during the summer, but not known to breed. Add**

Gavia imber.  
 Aythya americana.  
 Charitonetta albeola.  
 Ardetta exilis.  
 Totanus flavipes.  
 Stellula calliope.  
 Astragalinus psaltria mexicanus.  
 Melospiza georgiana.

Omit

Plegadis guarauna.  
 Callipepla squamata.  
 Philohela minor.  
 Phalænoptilus nuttallii nitidus.  
 Seiurus aurocapillus.

Page 13. **7. Migrants.** Add

*Gavia adamsii*.  
*Branta canadensis minima*.  
*Porzana jamaicensis*.  
*Astragalinus tristis pallidus*.  
*Piranga erythromelas*.  
*Dendroica palmarum*.

Omit

*Harporhynchus bendirei*.

Page 14. **8. Stragglers.** Add

*Gavia adamsii*.  
*Gavia arctica*.  
*Somateria dresseri*.  
*Branta canadensis minima*.  
*Plegadis autumnalis*.  
*Ardea egretta*.  
*Porzana jamaicensis*.  
*Nyctala tengmalmi richardsoni*.  
*Bubo virginianus arcticus*.  
*Coccyzus americanus*.  
*Dryobates pubescens*.  
*Stellula calliope*.  
*Acanthis linaria rostrata*.  
*Astragalinus psaltria mexicanus*.  
*Ammodramus leconteii*.  
*Melospiza georgiana*.  
*Piranga erythromelas*.  
*Dendroica palmarum*.  
*Geothlypis agilis*.  
*Geothlypis trichas*.  
*Wilsonia canadensis*.

Omit

*Sylvania pusilla pileolata*.  
*Harporhynchus bendirei*.

Page 15. **10. Rare or irregular visitants, from the east or southeast.** Add

*Branta canadensis minima*.  
*Plegadis autumnalis*.



*Ardea egretta.*  
*Tympanuchus americanus.*  
*Syrnium nebulosum.*  
*Ammodramus leconteii.*  
*Melospiza georgiana.*  
*Zamelodia ludoviciana.*  
*Piranga erythromelas.*  
*Dendroica palmarum.*  
*Geothlypis agilis.*  
*Geothlypis trichas.*  
*Wilsonia canadensis.*

Page 16. 12. **Rare or irregular visitants, from the west or southwest.** Add

*Stellula calliope.*  
*Astragalinus psaltria mexicanus.*

Add the star (\*) to denote breeding, to  
*Plegadis guarauna.*

Page 16

### SUMMARY.

|                                                              |     |
|--------------------------------------------------------------|-----|
| Total species in Colorado                                    | 387 |
| 1. Residents                                                 | 93  |
| 2. Regular winter visitants from the north                   | 23  |
| 3. Regular breeders that sometimes occur in winter           | 17  |
| 4. Rare or accidental winter visitants                       | 28  |
| 5. Summer residents                                          | 243 |
| A. Breeding on plains and in mountains                       | 101 |
| B. Breeding on plains, but not in mountains                  | 43  |
| C. Breeding in mountains, but not on plains                  | 56  |
| D. Breeding principally in mountains, sparingly<br>on plains | 21  |
| E. Breeding regularly only in southern Colorado              | 22  |
| 6. Summer visitants, not known to breed                      | 18  |
| 7. Migrants                                                  | 63  |
| 8. Stragglers                                                | 67  |
| 9. Regular visitants from east and southeast                 | 14  |
| 10. Rare visitants from east and southeast                   | 46  |
| 11. Regular visitants from west and southwest                | 20  |
| 12. Rare visitants from west and southwest                   | 14  |

## BIBLIOGRAPHY OF COLORADO ORNITHOLOGY.

---

Page 21. Add. AIKEN, C. E. *Otocoris alpestris arenicola*.  
*Colorado Springs Gazette* (local newspaper), Feb. 8, 1899.  
 Habits of this bird during cold weather.

Page 22. Add. ANTHONY, A. W. A new subspecies of the  
 Genus *Dryobates*. *Auk*, *XIII*. 1896, p. 32.

Describes the subspecies *Dryobates villosus montanus*. Rocky Mountain Woodpecker with the type from Boulder, Colorado. In *Auk*, *XV*. 1898, p. 54, Anthony changes *montanus* to *monticola*, and as such this subspecies has been recognized by the A. O. U.

Page 22. Add. BAIRD, S. F. Smithsonian Miscellaneous Collections, 181, Review of American Birds in the Museum of the Smithsonian Institution. Part I. North and Middle America. Washington Smithsonian Institution, 1864-66, pp. IV., 450.

Contains incidental records of a few species of birds taken in Colorado.

BANGS, OUTRAM. A Review of the Three-toed Woodpeckers of North America. *Auk*, *XVII*. 1900, p. 126.

Description of *Picoides americanus dorsalis*, with notes on nine specimens taken in Colorado.

Page 26. Add. BREWSTER, WM. Lewis's Woodpecker Storing Acorns. *Auk*, *XV*. 1898, p. 188.

Habits of the birds as noted near Denver, Colorado, and reported to him by Manly Hardy.

Page 26. Add. CHRISTIE, N. R. The Pinon Jay. *Osprey*, *III*. 1898, p. 57.

Short account of its breeding habits near Rouse Junction, Colorado.

Page 27. Add. COOKE, W. W. The State Agricultural College, The Agricultural Experiment Station, Bulletin No. 44, Technical Series No. 4, Further Notes on the Birds of Colorado, An Appendix to Bulletin No. 37, on the Birds of Colorado. By W. W. Cooke. Approved by the Station Council. Alston Ellis, President. Fort Collins, Colorado, March,



1898. The Smith-Brooks Printing Company, Denver, pp. 145-176. [Date of distribution, March, 1898.]

Adds eleven new species to the state list; references to 15 books and articles; additional notes on 98 species.

COOKE, W. W. The Scarlet Ibis—A Correction. *Auk*, XV. 1898, p. 183.

Statement that the specimens of Scarlet Ibis reported in the *Auk*, XIV. 1897, p. 316, proved to be the White-faced Glossy Ibis.

COOKE, W. W. A New Bird for Colorado. *Osprey*, III. 1898, p. 13.

A Le Conte's Sparrow taken by E. Carter at Breckenridge, October 2, 1886. It is stated that this is the first mountain record, but this is an error, as Merrill, *Auk*, XV, 1898, p. 16, had just previously recorded it from Idaho, west of the mountains, but at a much lower altitude. Breckenridge is 9,500 feet altitude. The article also contains records at Breckenridge of the Slate-colored Sparrow, Mockingbird and Bobolink.

COOKE, W. W. More New Birds for Colorado. *Auk*, XVI. 1899, p. 187.

Adds three new species to the state list, *Branta canadensis minima*, *Astragalinus psaltria mexicanus* and *Junco montanus*.

Page 29. Add. DILLE, F. M. Nesting of the Pine Siskin at Denver, Colo. *The Condor*, II. 1900, p. 73.

Several nests in the spring of 1899 within the city limits of Denver.

Page 31. Add. FREMONT, JOHN C. Report of the Exploring Expedition to the Rocky Mountains in the year 1842, and to Oregon and north California in the years 1843-4. By Brev. Capt. J. C. Fremont of the topographical engineers, under the orders of Col. J. J. Abert, chief of the topographical bureau. Printed by order of the House of Representatives, Washington; Blair & Rives, printers. 1845, p. 586.

Capt. Fremont crossed the State by way of the Grand river and the South Platte. His narrative contains only a few unimportant references to Colorado birds.

Page 31. Add. GILMORE, L. D. Western Goshawk in Colorado. *Osprey*, III. 1898, p. 28.

One shot at Sweetwater Lake, Garfield county, Colorado, February 12, 1898, by J. T. Meirer, and identified by the Smithsonian as *striatulus*. Two others seen later.

GILMORE, L. B. Some Notes on Colorado Birds. *Bul. Mich. Orn. Club*. II. April, 1898, p. 19.

Notes on seventeen species of birds seen in the vicinity of Dotsero, Colorado.

GILMORE, L. B. Notes on the Western Yellow-throat and Amer-

ican Raven in Colorado. *Bul. Mich. Orn. Club*, III. January, 1899, p. 8.

Notes on these two species seen near Dotsero.

Page 32. Add. HOWE, R. H., JR. Ranges of *Hylocichla fuscescens*, and *Hylocichla fuscescens salicicola* in North America. *Auk*, XVII. 1900, p. 22.

Measurements of two specimens of *salicicola* taken in Colorado.

Page 32. Add. INGERSOLL, EARNEST. Knocking Round the Rockies. Harper Bros., N. Y., 1883.

Contains descriptive notes on several Colorado birds.

Page 33. Add. "J." [CAPT. P. M. THORNE.] Snipe Wintering in Colorado. *Forest and Stream*. February 15, 1882.

Two Wilson's Snipe (*Gallinago delicata*) found February 3, 1882, at Fort Lyon, Colorado. The gizzard of the one shot contained partly digested fish.

Page 33. Add. JOHNSON, H. C. In the Breeding Home of Clarke's Nutcracker (*Nucifraga columbianus*). *The Condor*, II. 1900, p. 49.

Mentions all the nests of this bird taken in Colorado previous to 1900.

JONES, LYND. The Songs of the Warblers. (*Mniotiltidæ*). Laboratory Bulletin No. 10. Oberlin College. Also issued as Wilson Bulletin No. 30. Oberlin, Ohio, March 20, 1900, p. 57.

Notes on all the Warblers known to occur in the United States, with specific references to several of them as occurring in Colorado.

JONES, P. L. Flammulated Owls. *Osprey*, III. 1898, p. 46.

Records of three more captures near Beulah, Colorado, and one set of eggs.

Page 33. Add. KEYSER, LEANDER S. Rocky Mountain Birds. *Popular Science*, XXXIV. 1900, p. 3.

Short account of several common birds seen near Manitou.

KEYSER, LEANDER S. Rocky Mountain Birds. N. Y. Evening Post (newspaper), September 2, 1899.

Observations on the birds near Colorado Springs and Manitou.

Page 35. Add. NASH, H. W. Our Winter Birds. *The Cactus*. (Local magazine, Pueblo, Colorado.) II, No. 1, 1892.

Notes on the winter birds of Pueblo.

Page 35. Add. NELSON, E. W. Description of a new Subspecies of *Meleagris gallopavo* and proposed changes in the nomen-



clature of certain North American Birds. *Auk*, *XVII*. 1900, p. 120.

Describes a new sub-species, *Meleagris gallopavo merriami*, and assigns to it the wild turkeys of southwestern Colorado.

Page 35. Add. OBERHOLZER, HARRY C. Description of a new North American Thrush. *Auk*, *XV*. 1898, p. 303.

Describes *H. u. almæ*, subsp. nov. and gives Colorado as included in its habitat. This subspecies has been rejected by the A. O. U.

OBERHOLZER, HARRY C. A Revision of the Wrens of the Genus *Thryomanes* Sclater. *Proc. U. S. Nat. Mus.*, *XXI*. No. 1153, 1898, p. 427.

Gives a new name, *Thryomanes bewickii eremophilus*, to the form that occurs in Colorado. Up to January, 1900, this had not been passed upon by the A. O. U.

Page 36. RIDGWAY, ROBERT. New Species, etc., of American Birds, II. Fringillidæ (continued). *Auk*, *XV*. 1898, p. 319.

Describes a new subspecies, *Calcarius lapponicus alascensis*, Alaskan Longspur, and includes Colorado in its habitat.

## THE HISTORY OF COLORADO ORNITHOLOGY.

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Page 41. Add.

1864 6. **Baird.** *Review of American Birds.* Adds *Lanius ludovicianus excubitorides* taken in Colorado by D. Thompson.

Page 42.

Under 1872. **Allen.** Omit *Lanius ludovicianus excubitorides*, as it had already been recorded by Baird in his *Review of American Birds*.

Page 48. Add.

1898. **Cooke.** *Osprey, III.* 1898, p. 13. *Ammodramus leconteii* taken by Carter at Breckenridge.

1899. **Cooke.** *Auk, XVI.* 1899, p. 187. *Astragalinus psaltria mexicanus* and *Branta canadensis minima* taken at Denver; *Junco montanus* taken at Pueblo.

1900. **Cooke.** *Colorado Experiment Station Bulletin No. 56.* The present publication contains the first records for Colorado of nine species as follows: *Gavia arctica*, *Ardetta egretta*, *Syrnium nebulosum*, *Astragalinus tristis pallidus*, *Geothlypis agilis*, *Geothlypis trichas* and *Wilsonia canadensis* by Aiken; *Plegadis autumnalis* by A. T. Allen; *Falco sparverius deserticolus* by Carter.

Page 48. **RECAPITULATION.** Add.

|        |                  |    |     |
|--------|------------------|----|-----|
| 1898.. | W. W. Cooke..... | 1  | 364 |
| 1898.. | W. W. Cooke..... | 10 | 374 |
| 1898.. | W. W. Cooke..... | 1  | 375 |
| 1899.. | W. W. Cooke..... | 3  | 378 |
| 1900.. | W. W. Cooke..... | 9  | 387 |



## THE BIRDS OF COLORADO.

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Page 49. 1. **Æchmophorus occidentalis.** WESTERN GREBE.

Two shot out of three seen on Sheldon's Lake, near Fort Collins, October 29, 1898, by Wils Black. One of them is now mounted in the museum of the Agricultural College.

This species has been seen by Edwin Carter in South Park, but not taken.

Page 49. 4. **Colymbus nigricollis californicus.** AMERICAN EARED GREBE.

Has been seen at Breckenridge in migration by Edwin Carter, and breeds abundantly in Middle Park. In the following pages many records of Mr. Carter are given which are not in a certain sense new records, since they would be implied by the knowledge of the occurrence of the species in neighboring localities, but they are entered here both as a record of Mr. Carter's wide study of Colorado birds in localities not visited by other naturalists, and to furnish additional proof of the correctness of previous published records. Breckenridge is on the Blue River at an elevation of 9,500 feet, and about fifty miles from the junction of the Blue and the Grand rivers. Most of Mr. Carter's records of "Middle Park" meant the country around the mouth of the Blue river, with an altitude of 7,000-7,500 feet. His expeditions cover considerable of South Park, but most of his collecting has been along the branches of the South Platte on the eastern side of the park at about 8,000 feet.

Page 50. 6. **Podilymbus podiceps.** PIED-BILLED GREBE.

Seen by Mr. Carter at Breckenridge in migration, but never known to breed there.

Page 50. 7. Change to **Gavia imber.** LOON.

This and many changes given later are made to conform with the present nomenclature of the American Ornithologists'

Union. In the remainder of these notes the words "Change to" will be omitted and merely the present name given.

Seen by Mr. Carter in Middle Park. Mr. L. B. Gilmore reports that one was shot in July, 1897, on Sweetwater Lake, was mounted and is now in the possession of Mr. John Root. This is the first summer record for Colorado.

Page 50. Add. 9. **Gavia arctica.** BLACK-THROATED LOON.

A northern species occurring as a rare fall and winter visitant to Colorado.

Mr. C. E. Aiken of Colorado Springs, contributes the following notes.

"Three small Loons were observed on Prospect Lake in the suburbs of Colorado Springs, in November, 1898, and all were shot by a local gunner. One which I subsequently examined proved to be of this species.

"I also examined in 1883 a specimen killed, I think, the previous fall near Colorado Springs.

"Colorado is within the probable winter range of the species, and it may be a regular visitant."

Page 50. Add. [10. **Gavia pacifica.** PACIFIC LOON.

One was shot in November, 1899, near Clayton, New Mexico, just over the Colorado line, and was presented by Mr. Jesse Harris to the museum of the Agricultural College at Fort Collins.

[This is the western form, not before recorded east of the Rocky Mountains.]

Page 50. Add. [11. **Gavia lumme.** RED-THROATED LOON.

The distribution of this species is given in the A. O. U. Check List as "Northern part of northern hemisphere, migrating southward in winter nearly across the United States." This would bring Colorado within the limits of its distribution, and hence it is one of the species that should be especially sought. It has been taken in Nebraska.

In the following pages about twenty such species are included as showing what will probably be found some day in Colorado, and to direct attention to them as species for future investigation.]

Page 50. 53. **Larus californicus.** CALIFORNIA GULL.

Mr. Carter's collection contains two specimens of this Gull; one taken April 28, 1884, in Middle Park at 7,000 feet, and the other taken at Denver, October 26, 1878.

Page 51. 54. **Larus delawarensis.** RING-BILLED GULL.

The present writer found this species breeding quite commonly June 18, 1898, at the San Luis Lakes at an altitude of 7,500, being more than a thousand feet above previous breeding records. Mr. Carter has never found them breeding nor seen them in fall migration, but in spring has seen them in both South and Middle Parks.



Page 51. 60. **Larus philadelphia.** BONAPARTE'S GULL.

Three more instances are known from Colorado Springs, Denver and Longmont. The one from Denver is in winter plumage. Mr. Carter has taken one in Middle Park in the spring, this being the first record for Colorado west of the range.

Page 51. 62. **Xema sabinii.** SABINE'S GULL.

Mr. Carter has a specimen taken September 26, 1886, on an alpine lake near Breckenridge at over 10,000 feet. Mr. Aiken killed one at Manitou Park, October 10, 1897.

Page 51. Add. [64. **Sterna tschegrava.** CASPIAN TERN.

"Nearly cosmopolitan; in North America breeding southward to Virginia, Lake Michigan, Texas, Nevada and California."—(A. O. U.) Has been taken in Nebraska and probably will later be added to Colorado birds.]

Page 51. 69. **Sterna forsteri.** FORSTER'S TERN.

Noted by Mr. Carter only in migration.

Page 51. Add. [70. **Sterna hirundo.** COMMON TERN.

This Tern occurs over all of North America, but chiefly east of the plains. Specimens of both young-of-the-year and old birds are in Mr. Bond's collection, taken at Cheyenne. It is also known from Kansas and Nebraska, so we may confidently expect that the future will add this to the list of Colorado birds.]

Page 52. [74. **Sterna antillarum.** LEAST TERN.

"Northern South America, northward to California, Minnesota and New England, and casually to Labrador, breeding nearly throughout its range."—(A. O. U.) Has been noted many times in both Nebraska and Kansas and undoubtedly comes into eastern Colorado, though up to the present it has no Colorado record.]

Page 52. Add. [121. **Phalacrocorax mexicanus.** MEXICAN CORMORANT.

"West Indies and Central America to southern United States; north in the interior to Kansas and southern Illinois."—(A. O. U.) There has also been a specimen reported from Nebraska, so it should be looked for in Colorado.]

Page 52. 125. **Pelecanus erythrorhynchos.** AMERICAN WHITE PELICAN.

Several late records indicate that these birds have not yet deserted Colorado. A flock of about forty was seen feeding on a small lake near Denver in the spring of 1898.

Mr. Carter has one taken at Breckenridge, August 10, 1892, has seen them in both Middle and South Parks, has seen them feeding on alpine lakes and even migrating over the mountain passes at 13,000 feet.

Page 52. Add. [126. **Pelecanus fuscus.** BROWN PELICAN.

One was taken July 12, 1899, near Cheyenne, Wyoming, and is now in the Bond collection.

Page 52. 129. **Merganser americanus.** AMERICAN MERGANSER.

Breeds at Breckenridge.

Page 53. 130. **Merganser serrator.** RED-BREASTED MERGANSER.

One taken by Mr. Carter in Middle Park is the first record west of the range in Colorado.

Page 53. 131. **Lophodytes cucullatus.** HOODED MERGANSER.  
Mr. Carter has one taken June 1, 1871, near Canon City.

Page 53. 132. **Anas boschas.** MALLARD.

Taken breeding by Mr. Carter in South and Middle Parks.

Page 53. In place of 133. **Anas obscura.** BLACK DUCK. Put  
134a. **Anas fulvigula maculosa.** MOTTLED DUCK.

Although no specimens of this duck taken in Colorado have been examined by the present writer, yet there can be no doubt that the three specimens reported really belong to this subspecies.

Page 53. 135. **Chaulelasmus streperus.** GADWALL.

Breeds in Middle Park, according to Mr. Carter.

Page 54. 137. **Mareca americana.** BALDPATE.

Seen by Mr. Carter in summer in Middle Park at 7,000.

Page 54. 139. **Nettion carolinensis.** GREEN-WINGED TEAL.

140. **Querquedula discors.** BLUE-WINGED TEAL.

141. **Querquedula cyanoptera.** CINNAMON TEAL.

142. **Spatula clypeata.** SHOVELLER.

These four species of ducks have all been found by Mr. Carter at Breckenridge in migration, but are none of them known by him to breed at that altitude, though all breed in the great mountain parks.

Page 55. 143. **Dafila acuta.** PINTAIL.

Mr. Carter has taken Pintails in Middle Park at a little over 7,000 feet.

Page 55. 144. **Aix sponsa.** WOOD DUCK.

Two occurrences near Cheyenne are reported by Mr. Bond, who says they are quite common in northern Wyoming. Mr. A. T. Allen has known several instances in the vicinity of Denver, but none of these were in the summer.



Page 55. 146. **Aythya americana.** REDHEAD.

Facts are accumulating which make it probable that this species will in the near future be accounted among the breeding birds of Colorado. Several of these birds stayed in the reservoir at City Park in Denver all the summers of 1898 and 1899, but there was nothing to indicate that they nested there. A red-headed duck, presumably of this species, a fine male, was shot at the San Luis Lakes, June 18, 1898. This species, as well as the Canvas-back, is known to breed from northern United States northward.

Page 55. 147. **Aythya vallisneria.** CANVAS-BACK.

Page 55. 148. **Aythya marila.** SCAUP DUCK.

Page 56. 149. **Aythya affinis.** LESSER SCAUP DUCK.

These three have been taken by Mr. Carter at Breckenridge in migration.

Page 56. 152. **Clangula islandica.** BARROW'S GOLDEN-EYE.

Mr. Carter reports these ducks as common breeders in Middle Park, and that he once found them nesting at Georgia Pass at an altitude of 10,000 feet. As recorded by Brewer, *B. N. O. C. IV.*, 1879, *p. 148*, Mr. Carter took in Colorado in 1876 the first eggs of this species known to science.

Page 56. 153. **Charitonetta albeola.** BUFFLE-HEAD.

In the Carter collection is a fine male taken in Middle Park April 14, 1877, and a female taken May 5, 1884. Mr. Carter says that later in 1884, sometime in July, in Middle Park, he took both male and female. The male was in such worn plumage that it was not saved. The female was kept and mounted, but is not now on hand. Known to breed from northern United States northward.

Page 56. 154. **Harelda hyemalis.** OLD-SQUAW.

On October 16, 1898, B. Haywood killed two at Calkins' Lake near Longmont. On October 23 he killed another at the same place. Skins of two of these are now at the capitol at Denver.

Page 57. 155. **Histrionicus histrionicus.** HARLEQUIN DUCK.

Mr. Carter has found it breeding in Middle Park and on the Blue river a little below Breckenridge at 9,200 feet altitude.

Page 57. 165. **Oidemia deglandi.** WHITE-WINGED SCOTER.

One was shot on Barr Lake near Denver, November 2, 1898, and reported by Mr. Fenton.

Page 57. 166. **Oidemia perspicillata.** SURF SCOTER.

Two were killed at Loveland on October 31, 1899, by Mr. H. A. Flynn of Denver.

A few days before, on October 22, Mr. L. B. Meek shot a fine male at Barr Lake near Denver. The female was with it, but was not secured. Three other specimens were known at the same place within the next week.

Page 57. 167. **Erismatura jamaicensis.** RUDDY DUCK.

At Breckenridge, Mr. Carter knows them only as migrants, though they nest but a little lower down toward the Park.

Page 58. 169. **Chen hyperborea.** LESSER SNOW GOOSE.

Once seen by Mr. Carter in Middle Park.

Page 58. 169a. **Chen hyperborea nivalis.** GREATER SNOW GOOSE.

One was killed by Mr. John F. Campion of Denver, at Boyd's Lake near Loveland, April 9, 1899. It was a female and is now in the capitol at Denver.

Page 58. Add. [169. 1. **Chen caerulescens.** BLUE GOOSE.

"Interior of North America, breeding on eastern shores of Hudson Bay and migrating south, in winter, through Mississippi valley to Gulf coast."—(A. O. U.) "Interior of North America east of the Rocky Mountains."—(Goss.) Noted from Kansas and Nebraska as not uncommon in fall and winter.]

Page 58. 171a. **Anser albifrons gambeli.** AMERICAN WHITE-FRONTED GOOSE.

There is one in the Carter collection taken in Middle Park, and Mr. Carter says that in migration he has sometimes seen them there in quite large numbers.

Page 58. 172. **Branta canadensis.** CANADA GOOSE.

In migration at Breckenridge and breeds in Middle Park.

Page 59. Add. 172c. **Branta canadensis minima.** CACKLING GOOSE.

There is one at the capitol in Denver, killed by Mr. John F. Campion at Loveland, April 10, 1898, and presented by him to the State Natural History Society.

Page 59. 180. **Olor columbianus.** WHISTLING SWAN.

One taken by Mr. Carter in Middle Park.

Page 60. Add. 186. **Plegadis autumnalis.** GLOSSY IBIS.

Accidental. A fine specimen of this bird in full plumage is



at Mr. A. T. Allen's in Denver. It was shot by him near Denver several years ago. This is the southern form and Denver is many miles north of its ordinary range. Mr. Aiken writes that Mr. B. G. Voight of Denver shot an adult male April 12, 1898, along the Arkansas river, three miles west of Salida. Mr. Voight has the mounted specimen still in his possession.

Page 60. 187. **Plegadis guarauna.** WHITE-FACED GLOSSY IBIS.

Several more records have been received. Two specimens were shot on Barr Lake near Denver, October 3, 1898. Four were shot in the fall at Twin Lakes at an elevation of 9,000 feet. Mr. A. T. Allen has a young-of-the-year taken near Denver. Mr. Carter has taken them in South and Middle Parks and at Twin Lakes, and there is a specimen at Glenwood Springs shot in the vicinity. These last two are the first records west of the range in Colorado.

Page 60. 188. **Tantalus loculator.** WOOD IBIS.

Mr. Carter has seen the wing and bill of one taken on the Blue river, twenty-five miles below Breckenridge, at about 8,000 feet.

Page 60. 190. **Botaurus lentiginosus.** AMERICAN BITTERN.

Found by Mr. Carter breeding in both Middle and South Parks.

Noted by Mr. A. D. Baker in the Wet Mountain valley at 8,000 feet.

Page 61. 191. **Ardetta exilis.** LEAST BITTERN.

A mounted specimen is now in Denver, taken by Mr. Rudolph Borchardt on Berkeley Lake near Denver, June 8, 1898. Mr. Carter has one taken in South Park, May 14, 1875, and Mr. A. D. Baker has seen one in the Wet Mountain valley at over 8,000 feet.

Page 61. 194. **Ardea herodias.** GREAT BLUE HERON.

Once found by Mr. Carter, breeding in Middle Park at 7,000 feet altitude, and it has been seen by Mr. A. D. Baker in the Wet Mountain valley at least a thousand feet higher.

Page 61. Add. 196. **Ardea egretta.** AMERICAN EGRET.

Rare or accidental in spring. Mr. C. E. Aiken writes as follows: "On May 12th, 1899, Mr. A. Gruber and Mr. F. Cikanck—taxidermists in my employ—reported seeing a single bird in a tall cottonwood tree five miles south of Colorado

Springs. As they are familiar with this species, as well as the more common *A. candidissima*, there appears no reason to doubt their identification.

Page 61. 197. ***Ardea candidissima***. SNOWY HERON.

So many records for Colorado are accumulating of this species that it must be counted as a regular summer visitant to the state, whether or not it breeds. Two more specimens are known from Denver; three known by Mr. Aiken at Colorado Springs the spring of 1899; one at Glenwood Springs the spring of 1898, while Mr. Carter has not only taken them in Middle and South Parks, but even at Twin Lakes at 9,000 feet. A male and female were taken together by Mr. Carter, May 12, 1896, on the Gunnison river.

Page 61. Add. [201. ***Ardea virescens***. GREEN HERON.

"Temperate North America."—(A. O. U.) Common summer resident of Nebraska and Kansas. Also known as common in the states west of Colorado. Should be noted before long from Colorado.

Page 61. 202. ***Nycticorax nycticorax nævius***. BLACK-CROWNED NIGHT HERON.

In 1875 Mr. Aiken found them breeding at the San Luis Lakes and secured eggs. The present writer also found them there in 1898. Mr. Carter has taken them in both Middle and South Parks. Mr. L. B. Gilmore saw them on Sweetwater Lake at 8,000 feet, which is one of the highest records for this species.

Page 62. 205. ***Grus canadensis***. LITTLE BROWN CRANE.

Mr. A. T. Allen has a mounted specimen, shot several years ago near Denver.

Page 62. 206. ***Grus mexicana***. SANDHILL CRANE.

Mr. Carter has known of their breeding in Middle Park to about 8,000 feet, and Mr. Baker saw some November 15, 1899, in the Wet Mountain valley at about the same altitude.

Page 63. Add. [208. ***Rallus elegans***. KING RAIL.

In Goss' "Birds of Kansas" this species is given as extending "West into Colorado." There seems to be an error about this, and there is at present no undoubted record of this bird in Colorado. Since, however, it is a common species in Kansas and Nebraska, nearly to the Colorado line, we may expect sooner or later to have the above record verified.]

Page 63. 212. ***Rallus virginianus***. VIRGINIA RAIL.

Taken by Mr. Aiken at the San Luis Lakes, June 30, 1875, and therefore breeding there at 7,500 feet. One was brought to Mr. Aiken that was shot February 16, 1899, at a spring five miles from Colorado Springs. It was a male in good condition,



though this was the middle of one of the severest winters ever known in Colorado, with the temperature many degrees below zero. Several were said to have been seen, and also a smaller, darker kind that was probably *carolina*. Has been seen by Mr. Baker in the Wet Mountain valley at over 8,000 feet.

Page 63. 214. **Porzana carolina.** SORA.

Taken by Mr. Carter at Breckenridge, and breeds from Middle Park up the Blue river to about 9,000 feet.

Page 63. Add. [215. **Porzana noveboracensis.** YELLOW RAIL.

"Chiefly eastern North America, north to Nova Scotia, Hudson Bay, etc., less commonly west to Nevada and California."—(A. O. U.) Thus by implication Colorado is included in its habitat, but it has not yet been found here. Known as not uncommon in Kansas and Nebraska.]

Page 63. 221. **Fulica americana.** AMERICAN COOT.

Breeds in Middle and South Parks, but known by Mr. Carter at Breckenridge only in migration.

Page 63. 223. **Phalaropus lobatus.** NORTHERN PHALAROPE.

Mr. Carter saw several in Middle Park at 7,000 feet, May 26, 1884. He has taken them at Breckenridge in migration.

Page 63. 224. **Steganopus tricolor.** WILSON'S PHALAROPE.

Two pairs were taken near Glenwood Springs during the spring of 1898. Mr. Carter has taken them in migration in both Middle and South Parks, but not at Breckenridge. On September 1, 1885, he took a young-of-the-year at timber line.

Page 64. 225. **Recurvirostra americana.** AMERICAN AVOCET.

At the same places where Aiken found them breeding in the San Luis valley in 1875, the present writer found them breeding in 1898. Mr. Carter says that he has found them breeding in South Park, and has taken them in migration at Breckenridge.

Page 64. 230. **Gallinago delicata.** WILSON'S SNIPE.

Mr. L. B. Gilmore reports it as remaining nearly every winter around Sweetwater Lake at 8,000 feet. About January 20, 1900, he saw nine at one time. It also breeds sparingly in that vicinity. At Breckenridge it has been noted only in migration.

Page 65. 233. **Micropalama himantopus.** STILT SANDPIPER.

Several more records have come to hand of this rare Sandpiper. Mr. Aiken took one at Colorado Springs, May 14, 1884.

Mr. Carter has one taken at Breckenridge, and has also taken them years ago in both Middle and South Parks.

Page 65. Add. [234. **Tringa canutus**. KNOT.

"Nearly cosmopolitan. Breeds in high northern latitudes, but visits the southern hemisphere during its migrations."—(A. O. U.) Should be looked for in Colorado, as it has been taken in both Kansas and Nebraska.]

Page 65. 241. **Tringa bairdii**. BAIRD'S SANDPIPER.

242. **Tringa minutilla**. LEAST SANDPIPER.

246. **Ereunetes pusillus**. SEMIPALMATED SANDPIPER.

All three have been taken by Mr. Carter in Middle and South Parks.

Page 66. 249. **Limosa fedoa**. MARBLED GODWIT.

Mr. Carter has taken them as high as Breckenridge, far above their ordinary range.

Page 66. 254. **Totanus melanoleucus**. GREATER YELLOW-LEGS.

Taken by Mr. Carter in migration in both Middle and South Parks, and by Mr. Baker in Wet Mountain valley, at least to 8,000 feet.

Page 66. 255. **Totanus flavipes**. YELLOW-LEGS.

Taken by Mr. Carter in migration in both Middle and South Parks.

Page 67. 256. **Helodromas solitarius**. SOLITARY SANDPIPER.

Page 67. 258a. **Symphemia semipalmata inornata**. WESTERN WILLET.

At Breckenridge Mr. Carter has noted it only in migration.

Page 67. Add. [262. **Tryngites subruficollis**. BUFF-BREASTED SANDPIPER.

"North America, especially in the interior."—(A. O. U.) Known from Kansas and Nebraska and should be taken in Colorado.

Page 67. 263. **Actitis macularia**. SPOTTED SANDPIPER.

Breeds at Breckenridge.

Page 67. 264. **Numenius longirostris**. LONG-BILLED CURLEW.

Taken by Mr. Carter at Breckenridge in migration, and found by him breeding in Middle and South Parks.



Page 68. 270. **Squatarola squatarola.** BLACK-BELLIED PLOVER.

In Mr. Bond's collection is a very fine specimen in *full breeding plumage*, taken at Cheyenne, May 21, 1898.

Page 68. 273. **Ægialitis vocifera.** KILLDEER.

Breeds at Breckenridge.

Page 68. 274. **Ægialitis semipalmata.** SEMIPALMATED PLOVER.

One in Mr. Carter's collection was shot from a large flock seen by him in the fall on Grand Lake in Middle Park.

Page 68. Add. [277a. **Ægialitis meloda circumcincta.** BELTED PIPING PLOVER.

There is one in the Bond collection, taken at Cheyenne, May 13, 1892, but although this is so close to Colorado, and it is known in both Kansas and Nebraska, yet up to the present time it has no record for this State.]

Page 68. Add. [278. **Ægialitis nivosa.** SNOWY PLOVER.

"Western United States, from California east to Kansas and western Gulf States."—(A. O. U.) Surely this ought to include Colorado, but it has no record here as yet.]

Page 68. 281. **Ægialitis montana.** MOUNTAIN PLOVER.

Mr. Carter has never seen them at Breckenridge, even in migration, but has found them breeding in South Park.

Page 69. 283. **Arenaria interpres.** TURNSTONE.

Eight of these birds were killed on Berkeley Lake near Denver, May 18, 1900, and four of them, two males and two females, were mounted by Mr. Rudolph Borchardt.

Page 69. 289. **Colinus virginianus.** BOB-WHITE.

Introduced about 1891 near Grand Junction and still occurs there, but not in anywhere near the numbers of the California Partridge. They occur in the Wet Mountain valley to at least 8,000 feet. They are native and not uncommon at Wray, in eastern Colorado on the plains.

Page 69. Add. [289b. **Colinus virginianus texanus.** TEXAN BOB-WHITE.

As its name implies, this is a Texas species, inhabiting southern and western Texas. It has been taken in southwestern Kansas. If it occurs anywhere in Colorado it would be in the extreme southeastern corner, along the Cimarron river. No ornithologist has ever penetrated this part of Colorado, which undoubtedly holds many new records for the fortunate one that explores it. It is fair to presume that of the dozen or fifteen species known to occur along the Cimarron a little further east, that have not yet been taken in Colorado, that several follow it up occasionally into this State. Whoever goes into that country should seek especially for the Lesser Prairie Hen, the Texan Bob-white, and settle definitely whether the Turkey of that region is the eastern form. So far as is known to the present writer, all of the Turkeys in the various collections in the State are referable to the Mexican form.

Page 69. 293. **Callipepla squamata.** SCALED PARTRIDGE.

A queer state of affairs has come to light in regard to the occurrence of this species in Colorado, that shows strongly how much there is yet to be learned about Colorado ornithology. In 1895 W. P. Lowe gave in the Auk the first published record of this species for Colorado. It was considered a rare specimen and extended the known range nearly three hundred miles north-eastward. Two years ago a specimen was sent to the present writer that was taken at Rocky Ford, but was supposed to have been introduced there. Now it has become known that they are common among the cedars on the higher arid lands back from the river and miles away from water. The cowboys that rode the range at least sixteen years ago, report that they were more plentiful there then than they are now. Lately they have been working toward the cultivated lands along the river, and during the winter of 1899-1900 they have become, in the vicinity of Rocky Ford, more common than the Bob-white. The Scaled Partridge should therefore be considered as resident; common locally.

Page 69. 294. **Lophortyx californicus.** CALIFORNIA PARTRIDGE.

A few years ago nearly a thousand of these birds were turned loose at Grand Junction. They have thriven wonderfully and the country now is full of them. They average two broods per year and the market gardeners claim they are a nuisance in their vegetable gardens.

Page 70. 295. **Lophortyx gambelii.** GAMBEL'S PARTRIDGE.

Page 70. 297. **Dendragapus obscurus.** DUSKY GROUSE.  
Breeds at Breckenridge.

Page 70. 300b. **Bonasa umbellus umbelloides.** GRAY RUFFED GROUSE.

At last the present writer has had the good fortune to see this bird with his own eyes. A family of old and young were seen August 12, 1899, on South Fork in Estes Park, at 9,000 feet elevation.

Page 70. 304. **Lagopus leucurus.** WHITE-TAILED PTARMIGAN.  
Breeds at Breckenridge.

Page 71. 305. **Tympanuchus americanus.** PRAIRIE HEN.

Resident. Further records of this species allow us now to include it among the breeders. Mr. Otto Derr writes that at



Wray the Prairie Hen is not an uncommon breeder, occurring there with the Sharp-tailed Grouse and Bob-white.

Page 71. 308b. **Pediœcetes phasianellus campestris.**  
PRAIRIE SHARP-TAILED GROUSE.

Mr. Carter says that they breed in Middle Park, but only in the lower parts, not above 7,500 feet. In winter they have been noted up to 9,500 feet.

Page 71. 309. **Centrocercus urophasianus.** SAGE GROUSE.

The highest that Mr. Carter has found them breeding is at Dillon, about 9,000 feet. In their migration, or more properly, wanderings, he has taken them at Breckenridge, and has even seen them crossing the main range at 14,000 feet.

Page 71. 310a. **Meleagris gallopavo fera.** WILD TURKEY.

As late as 1898 Turkeys were seen in Wet Mountain valley, and though they are entered here as belonging to the eastern form this is without sure proof, and the line in Colorado separating the two forms has not yet been settled.

Page 72. 310. **Meleagris gallopavo.** MEXICAN TURKEY.

The Turkey in Mr. Carter's collection is a well marked specimen of the western bird, though taken on the Atlantic slope in South Park in January, 1878.

Page 72. 312. **Columba fasciata.** BAND-TAILED PIGEON.

Mr. Carter has found them nesting in South Park, but has never seen them at Breckenridge. The present writer saw a flock of eight at Mary's Lake in Estes Park in August, 1898, and a single bird at the same place the next August.

Page 73. Add. [315. **Ectopistes migratorius.** PASSENGER PIGEON.

"Eastern North America, from Hudson Bay southward, and west to the Great Plains, straggling thence to Nevada and Washington."—(A. O. U.) It would be strange if the true eastern Pigeon did not occur occasionally in Colorado, and it has several times been reported here. All of these records or statements, when followed up, prove to be the Band-tailed Pigeon.]

Page 73. 316. **Zenaidura macroura.** MOURNING DOVE.

Breeds at Breckenridge.

Page 73. 319. **Melopelia leucoptera.** WHITE-WINGED DOVE.

One was shot by Mr. A. D. Baker in the Wet Mountain valley in September, 1899. This is the fourth record for Colorado, and makes it probable that the bird is not a mere straggler to the State.

Page 73. Add. [326. **Catharista urubu.** BLACK VULTURE.

"South Atlantic and Gulf States, \* \* \* west to the Great Plains, \* \* \* straggling north to South Dakota."—(A. O. U.) Has been taken in western Kansas and probably will some time be found as a rare summer visitant in southeastern Colorado.]

Page 73. 331. **Circus hudsonius.** MARSH HAWK.

Breeds to at least 8,000 feet, near Breckenridge.

Page 74. 332. **Accipiter velox.** SHARP-SHINNED HAWK.

Breeds at Breckenridge.

Page 74. 333. **Accipiter cooperi.** COOPER'S HAWK.

Not known by Mr. Carter to breed at Breckenridge, though not uncommon as a breeder a little lower in Middle Park.

Page 74. 334. **Accipiter atricapillus.** AMERICAN GOSHAWK.

Occurs at Breckenridge both in summer and in winter.

Page 74. 334a. **Accipiter atricapillus striatulus.** WESTERN GOSHAWK.

One was shot at Sweetwater Lake, Garfield county, February 12, 1898, by Mr. J. T. Meirer, and identified by the Smithsonian. Two others were seen later. One was taken near Colorado Springs in winter, and is now in Mr. Aiken's collection. Mr. Carter has quite a collection of Goshawks taken in the vicinity of Breckenridge, largely intermediates, but nearly half of them would be classed under the head of *striatulus*.

Page 75. 337b. **Buteo borealis calurus.** WESTERN RED-TAIL.

Page 75. 342. **Buteo swainsoni.** SWAINSON'S HAWK.

Page 75. 348. **Archibuteo ferrugineus.** FERRUGINOUS ROUGH-LEG.

Page 75. 349. **Aquila chrysaetos.** GOLDEN EAGLE.

These four are represented in the Carter collection and all breed at Breckenridge.

Page 76. 352. **Haliaeetus leucocephalus.** BALD EAGLE.

Mr. Carter has known of its breeding at Breckenridge and nearly to 10,000 feet.

Page 76. 360. **Falco sparverius.** AMERICAN SPARROW HAWK.

A Sparrow Hawk in the collection of the Agricultural College at Fort Collins, taken on the plains near there, is referable to the eastern form, but shows a tendency toward the western. Of five adult birds in Mr. Carter's collection, taken in the moun-



tains, two are eastern and three western. One of the eastern birds was taken east of the range and the other west.

Page 76. Add. 360a. **Falco sparverius deserticolus.**  
DESERT SPARROW HAWK.

Resident. Two adult males and one adult female in Mr. Carter's collection are clearly referable to the western form. They were taken in Middle and South Parks.

Page 77. 364. **Pandion haliaetus carolinensis.** AMERICAN OSPREY.

Mr. Carter has seen them at Breckenridge, and knows of their nesting as high as 8,500 feet, on the Blue river.

Page 77. 365. **Strix pratincola.** AMERICAN BARN OWL.

One has been seen by Mr. A. D. Baker in the Wet Mountain valley. An adult female was shot at Rocky Ford in June, 1898, and is now in the collection of A. J. Dean.

Page 77. 366. **Asio wilsonianus.** AMERICAN LONG-EARED OWL.

Common near Breckenridge.

Page 77. 367. **Asio accipitrinus.** SHORT-EARED OWL.

Has been taken at Breckenridge in winter.

Page 77. Add. 368. **Syrnium nebulosum.** BARRED OWL.

Resident. A common species of eastern United States, west to Nebraska and Kansas, now first added to Colorado birds by the following note from Mr. C. E. Aiken:

"In March, 1897, Mr. B. G. Voight found a pair of these Owls breeding near Holyoke, in the northeast corner of the state. Two eggs, somewhat incubated, and one of the birds were secured."

Page 77. 371. **Nyctala tengmalmi richardsoni.** RICHARDSON'S OWL.

A second specimen for Colorado is the one taken by Mr. Carter at Breckenridge, December 28, 1882, and now in his collection.

Page 77. 372. **Nyctala acadica.** SAW-WHET OWL.

Mr. Carter's collection contains an adult taken at Breckenridge and also a young-of-the-year taken there August 10, 1884. Though Mr. Carter has seen no nests at Breckenridge, there can be little doubt that they breed there.

As the present writer was working on this part of this bulletin, January 31, 1900, one of our students caught a fine specimen in his hands in one of the evergreens near the main College building.

Page 78. 374. **Megascops flammeola.** FLAMMULATED SCREECH OWL.

Nine new records for Colorado and four instances of breeding can be added to the fourteen previous specimens known. P. L. Jones reports one found dead May 1, 1898; a female and two fresh eggs that proved infertile, June 27, 1898; a young male caught by a cat, September 12, 1898; a female and three eggs incubated about four days, June 5, 1899. All four cases were near Beulah, at less than 7,000 feet. Capt. D. B. Ingraham reports finding a female and two fresh eggs June 2, 1898, and two days later a female and two slightly incubated eggs, the latter within a hundred yards of where a female and three eggs were taken in 1897, near Beulah. Mr. C. E. Aiken reports two more specimens from Colorado Springs; one of these, taken on Fountain Creek, is the first summer specimen for the plains. There is one in the Carter collection, taken at Breckenridge, October 4, 1894. These make twenty-three records for Colorado and ten instances of nesting.

Page 80. 375b. **Bubo virginianus arcticus.** ARCTIC HORNED OWL.

Mr. Aiken reports a fine specimen killed near Colorado Springs, November 28, 1898. Another one said to have been seen. These notes of course refer to the lighter mountain form.

Up to the time of the issue of this bulletin, the A. O. U. has come to no conclusion in regard to what name shall be applied to this variety.

Horned Owls are common at Breckenridge, but in Mr. Carter's quite extensive series there are none of the lighter form.

Page 80. 376. **Nyctea nyctea.** SNOWY OWL.

Has been reported to Mr. Carter as taken near Breckenridge. The most southern record to date in Colorado is one known by Mr. Baker to have been seen in the Wet Mountain valley.

Page 81. 378. **Speotyto cunicularia hypogæa.** BURROWING OWL.

One in the Carter collection, taken in Middle Park.

Page 81. 379. **Glaucidium gnoma.** PYGMY OWL.

Mr. Carter reports it as breeding at Breckenridge.



Page 81. 385. **Geococcyx californianus.** ROAD-RUNNER.

There is one in the Carter collection that was taken on the Arkansas above Canon City. Mr. Carter saw one several years ago near Littleton, which is the most northern record for the State.

Page 82. 387a. **Coccyzus americanus occidentalis.** CALIFORNIA CUCKOO.

Taken by Mr. Carter in Middle Park.

Page 82. 390. **Ceryle alcyon.** BELTED KINGFISHER,

Mr. L. B. Gilmore records one that wintered in 1897-8 near the outlet of Sweetwater Lake, at about 8,000 feet.

Breeds at Breckenridge.

Page 82. 393e. **Dryobates villosus monticola.** ROCKY MOUNTAIN HAIRY WOODPECKER.

This the present name given to the common form that occurs in Colorado. Breeds at Breckenridge.

Page 82. 394c. **Dryobates pubescens medianus.** DOWNY WOODPECKER.

If the eastern form really occurs in Colorado, it would be of this subspecies.

Page 83. 394b. **Dryobates pubescens homorus.** BATCHELDER'S WOODPECKER.

Page 83. 401b. **Picoides americanus dorsalis.** ALPINE THREE-TOED WOODPECKER.

Page 83. 402a. **Sphyrapicus varius nuchalis.** RED-NAPED SAPSUCKER.

Page 84. 404. **Sphyrapicus thyroides.** WILLIAMSON'S SAPSUCKER.

The last four species are all represented in Mr. Carter's collection, and have been taken by him as breeders at Breckenridge.

Page 84. 405a. **Ceophlæus pileatus abieticola.** NORTHERN PILEATED WOODPECKER.

This becomes now the name of the Colorado bird.

Page 84. 406. **Melanerpes erythrocephalus.** RED HEADED WOODPECKER.

Taken at Breckenridge by Mr. Carter, but not known to breed there.

Page 84. 408. **Melanerpes torquatus.** LEWIS'S WOODPECKER.

The statement of breeding for this species is a misprint. It should be: Breeds late in May. In calling attention to the error, Mr. Walter Blanchard of Boulder, writes that the earliest eggs he has known at Boulder were May 10, and the latest, June 14. Mr. Carter has seen the birds at Breckenridge, but does not know of their nesting there.

Page 84. 409. **Melanerpes carolinus.** RED-BELLIED WOODPECKER.

One was taken by Mr. C. E. Aiken near Limon in May, 1899.

Page 85. 412a. **Colaptes auratus luteus.** NORTHERN FLICKER.

It is probable that the Colorado bird should be referred to this form.

Page 85. 413. **Colaptes cafer.** RED SHAFTED FLICKER.

Breeds at Breckenridge.

Page 85. 418. **Phalænoptilus nuttallii.** POOR-WILL.

Mr. Carter reports their breeding in Middle Park.

Page 85. 420a. **Chordeiles virginianus henryi.** WESTERN NIGHTHAWK.

Page 86. 425. **Aeronautes melanoleucus.** WHITE-THROATED SWIFT.

Both these last two breed at Breckenridge.

Page 86. 429. **Trochilus alexandri.** BLACK-CHINNED HUMMINGBIRD.

Mr. Wm. Cross took a fine male at Glenwood Springs in 1898. This is the most northeasterly record to date.

Page 86. 432. **Selasphorus platycercus.** BROAD-TAILED HUMMINGBIRD.

Breeds at Breckenridge.

Page 86. 433. **Selasphorus rufus.** RUFOUS HUMMINGBIRD.

One was taken by Mr. Carter at Breckenridge, and it probably breeds there, though he has never found its nest.

Page 87. 436. **Stellula calliope.** CALLIOPE HUMMINGBIRD.

One of the most surprising specimens in Mr. Carter's collection is a fine Calliope Hummer taken near Breckenridge, June



30, 1882, at an altitude of about 9,500 feet. This is the second record for Colorado.

Page 87. 444. **Tyrannus tyrannus.** KINGBIRD.

Breeds in Middle Park, according to Mr. Carter.

Page 87. 447. **Tyrannus verticalis.** ARKANSAS KINGBIRD.

Mr. Carter has seen them at Breckenridge in migration, and knows of their breeding in Middle Park.

Page 87. 448. **Tyrannus vociferans.** CASSIN'S KINGBIRD.

Occurs in migration at Breckenridge and breeds only a little lower, nearly to 9,000 feet.

Page 87. 454. **Myiarchus cinerascens.** ASH-THROATED FLYCATCHER.

The known northeastern range of this bird has been considerably extended by a specimen in the Bond collection, taken at Cheyenne, Wyoming, June 6, 1896.

Page 88. 457. **Sayornis saya.** SAY'S PHOEBE.

Mr. Carter has taken it at Breckenridge, but does not know of its breeding there.

Page 88. 459. **Contopus borealis.** OLIVE SIDED FLYCATCHER.

Page 88. 462. **Contopus richardsonii.** WESTERN WOOD PEWEE.

Page 88. 464. **Empidonax difficilis.** WESTERN FLYCATCHER.

Page 88. 466. **Empidonax traillii.** TRAILL'S FLYCATCHER.

Of these four, the first three breed at Breckenridge, while the last occurs there in migration, but has not been noted breeding.

Page 89. 468. **Empidonax hammondi.** HAMMOND'S FLYCATCHER.

Known by Mr. Carter to breed as high as Dillon at 9,000 feet.

Page 89. 469. **Empidonax wrightii.** WRIGHT'S FLYCATCHER.

Occurs at Breckenridge in migration, but not known by Mr. Carter to breed there.

Page 89. 474c. **Otocoris alpestris arenicola.** DESERT HORNED LARK.

During February, 1899, Colorado experienced the most severe weather on record. Along the foothills from Fort Collins

to Colorado Springs the mercury fell to thirty below zero F. or lower. For two weeks or more, countless thousands of the Horned Larks flocked into the towns in search of food, and many thousands died of cold and hunger. Around the flour mills and elevators they came in clouds. Many persons made special provision for feeding them, one man giving them more than three thousand pounds of grain. Mr. Carter ascribes to this form the birds that breed at Breckenridge.

Page 89. 475. **Pica pica hudsonica.** AMERICAN MAGPIE.

Mr. Carter found them at Breckenridge breeding almost to timber line, at 10,500 feet.

Page 90. 478b. **Cyanocitta stelleri macrolopha.** LONG-CRESTED JAY.

At Boulder, Mr. Blanchard has taken the earliest sets of eggs May 11, 1896, May 15, 1897, and May 10, 1898.

Mr. Carter notes their breeding at Breckenridge.

Page 90. 484a. **Perisoreus canadensis capitalis.** ROCKY MOUNTAIN JAY.

Page 91. 486. **Corvus corax sinuatus.** AMERICAN RAVEN.

Both breed at Breckenridge.

Page 91. 487. **Corvus cryptoleucus.** WHITE-NECKED RAVEN.

There is one in the Carter collection, taken at Dillon in the fall of 1872. At that time they were quite common, Mr. Carter says, but have since disappeared.

One was seen by Mr. A. D. Baker in the Wet Mountain valley a few years ago. Mr. C. E. Aiken learned at Limon, out on the plains east of Colorado Springs, that one was seen there about ten years ago.

Page 92. 488. **Corvus americanus.** AMERICAN CROW.

Has been taken by Mr. Carter at Breckenridge, but is not known to breed there. Usually seen singly.

Page 92. 491. **Nucifraga columbiana.** CLARKE'S NUT-CRACKER.

Breeds at Breckenridge.

Page 93. 492. **Cyanocephalus cyanocephalus.** PINON JAY.

Mr. Carter has seen them at Breckenridge in the fall, but during the summer season has not found them there or in either Middle or South Park.



Page 93. 494. **Dolichonyx oryzivorus.** BOBOLINK.

To the few records of this bird in Colorado Mr. Carter now adds two more. One was taken in Middle Park May 20, 1884, at 7,000 feet, and one taken in South Park May 21, 1876, at about 8,000 feet. These are farther west and at a higher altitude than any previous Colorado records. Mr. C. E. Aiken saw a female at Limon in May, 1899.

Page 93. 495. **Molothrus ater.** COWBIRD.

Page 93. 497. **Xanthocephalus xanthocephalus.** YELLOW-HEADED BLACKBIRD.

Page 94. 498. **Agelaius phœniceus.** RED-WINGED BLACKBIRD.

All three of these Blackbirds have been found by Mr. Carter breeding in Middle and South Parks, and all have been taken at Breckenridge, but only in migration.

Page 94. 501b. **Sturnella magna neglecta.** WESTERN MEADOWLARK.

Breeds at Breckenridge.

Page 95. 508. **Icterus bullocki.** BULLOCK'S ORIOLE.

Seen by Mr. Carter in Middle Park, but contrary to what would be expected, he has never seen it at Breckenridge.

Page 95. 510. **Scolecophagus cyanocephalus.** BREWER'S BLACKBIRD.

Breeds at Breckenridge.

Page 95. 514a. **Coccothraustes vespertinus montanus.** WESTERN EVENING GROSBEAK.

The record is now complete for Colorado for every month in the year. They had been seen in the State from the first week in August until late in May. On June 19, 1898, Mr. C. E. Aiken found a flock of twenty-five to thirty birds in the foothills near Colorado Springs. He killed five males. The testicles of each were the size of a bean, and it was evident that the birds were breeding in the mountains and had come down to feed on the insect larvæ that were ravaging the young oak leaves. The year is completed by the record of Mr. L. A. Test of the Agricultural College at Fort Collins, who on July 22, 1899, and again the next day, in Estes Park, saw a party of eight, apparently three old birds and five young ones. Mr. P. L. Jones of Beulah reports that during May and June, 1898, these birds were constantly around his premises. Late in June he saw a flock of seventeen,

composed of male and female and some birds which seemed to to be young-of-the-year, but were not captured for certain identification.

On the strength of these records this species will be classed as resident in Colorado.

Page 96. 515a. **Pinicola enucleator montana.** ROCKY MOUNTAIN PINE GROSBEAK.

Breeds at Breckenridge.

Page 96. 518. **Carpodacus cassinii.** CASSIN'S PURPLE FINCH.

An abundant breeder at Breckenridge. Mr. Carter once found a male in immature plumage breeding with a mature female.

Page 97. 521a. **Loxia curvirostra stricklandi.** MEXICAN CROSSBILL.

A female or young-of-the-year male was seen by the present writer at Lamar, July 15, 1898. It seemed in perfect health and was probably an accidental wanderer who found himself here on the plains, one hundred and fifty miles east of the foothills. Breeds at Breckenridge.

Page 97. 524. **Leucosticte tephrocotis.** GRAY-CROWNED LEUCOSTICTE.

Page 98. 524a. **Leucosticte tephrocotis littoralis.** HEPBURN'S LEUCOSTICTE.

Page 98. 526. **Leucosticte australis.** BROWN-CAPPED LEUCOSTICTE.

Page 98. 528. **Acanthis linaria.** REDPOLL.

All four of these species have been taken in migration at Breckenridge by Mr. Carter, while the Brown-capped Leucosticte is an abundant breeder on the mountain tops above Breckenridge.

Page 98. 229. **Astragalinus tristis.** AMERICAN GOLDFINCH.

Mr. Carter considers this a rare bird at Breckenridge, where he has seen it only in migration.

Page 99. Add. 529a. **Astragalinus tristis pallidus.** WESTERN GOLDFINCH.

Migratory; probably common. It is undoubtedly a summer resident, but until this fact is definitely ascertained it will be classed among the migrants according to the present record. Added to Colorado birds by Mr. C. E. Aiken, who writes:



"This paler Western Goldfinch occurs in Colorado as well as the typical eastern form to which all have heretofore been referred. I am not able at present to define their relative range or abundance with certainty. *Pallidus* is an early spring migrant along the eastern base of the mountains, and quite likely may be the alpine breeder. *Tristis* probably is a summer visitor from the southeast, occupying the plains to the base of the mountains. I have obtained both forms at Colorado Springs, and *tristis* one hundred miles eastward. Examples of both forms, which I recently sent to the American Museum of Natural History, have been kindly identified by Mr. Chapman with the concurrence of Dr. Allen."

Page 99. 530. **Astragalinus psaltria.** ARKANSAS GOLDFINCH.

Mr. Wm. Cross found this form breeding at Glenwood Springs during the summer of 1898. Mr. Aiken saw a very early flock at Colorado Springs May 13, 1898.

Page 99. 530a. **Astragalinus psaltria arizonæ.** ARIZONA GOLDFINCH.

Found by Mr. Wm. Cross breeding at Glenwood Springs during the summer of 1898. This is the most northwestern record in Colorado.

Page 99. Add. 530b. **Astragalinus psaltria mexicanus.** MEXICAN GOLDFINCH.

One taken by Mr. A. T. Allen in Denver and identified by Prof. J. A. Allen. There is also one in Mr. C. E. Aiken's collection taken near Colorado Springs. Near Trinidad, in June, 1898, the present writer is very sure that he saw two of them, though he failed to secure either of them. The species is entered as seen in summer but not known to breed. This is according to the present record, but it is with the belief that the species occurs at Trinidad as a regular summer resident.

Page 99. 533. **Spinus pinus.** PINE SISKIN.

One of the few nests ever found on the plains is the one taken by Mr. F. M. Dille in the outskirts of Denver during the summer of 1898. Mr. Carter has taken it at Breckenridge.

Page 99. 000. **Passer domesticus.** EUROPEAN HOUSE SPARROW.

Miss Myra Eggleston reports that they reached Grand Junction during the fall of 1899, a flock of a dozen being seen. This is the first record for Colorado west of the range, and there

is nothing to indicate whether these birds reached Grand Junction from eastern Colorado or have come eastward from Utah. The distance is less from where they occur in Utah, and the mountain passes much lower.

Page 100. 534. ***Passerina nivalis***. SNOWFLAKE.

Mr. Carter took one December 28, 1894, between Breckenridge and Middle Park at about 8,000 feet.

Page 100. 536a. ***Calcarius lapponicus alascensis***. ALASKAN LONGSPUR.

This is the new name for the form of the Lapland Longspur that occurs in Colorado. It was seen but once by Mr. Carter at Breckenridge, where he took one, March 21, 1894, in the midst of a snowstorm. One has been seen by Mr. Baker in the Wet Mountain valley at over 8,000 feet.

Page 101. 540a. ***Poæcetes gramineus confinis***. WESTERN VESPER SPARROW.

Page 101. 542b. ***Ammodramus sandwichensis alaudinus***. WESTERN SAVANNA SPARROW.

Both breed at Breckenridge.

Page 102. Add. 548. ***Ammodramus leconteii***. LECONTE'S SPARROW.

The rarest find in the Carter collection is a specimen of this Sparrow, taken at Breckenridge October 24, 1886. This is the first record for Colorado, and its occurrence in the mountains three hundred miles west of its usual prairie home is of course accidental. This is the only record in the United States west of the main range, except the one noted by Merrill, *Auk*, XV. 1898, p. 16, taken in Idaho. Though Merrill's bird was reported first, Carter's was taken many years the earlier.

Page 102. 552a. ***Chondestes grammacus strigatus***. WESTERN LARK SPARROW.

Breeds at Breckenridge.

Page 102. 553. ***Zonotrichia querula***. HARRIS'S SPARROW.

The second record for Colorado of this bird is the one seen by the present writer at Holly, May 10, 1898. It was migrating in company with White-crowned Sparrows.

Page 102. 554. ***Zonotrichia leucophrys***. WHITE-CROWNED SPARROW.

Breeds at Breckenridge.



Page 103. 559a. **Spizella monticola ochracea.** WESTERN TREE SPARROW.

Occurs at Breckenridge in migration.

Page 103. 560a. **Spizella socialis arizonæ.** WESTERN CHIPPING SPARROW.

Breeds at Breckenridge.

Page 104. Add. [563a. **Spizella pusilla arenacea.** WESTERN FIELD SPARROW.

"Great Plains, from Texas to Montana and Dakota."—(A. O. U.) A common summer resident of Kansas and Nebraska. Undoubtedly occurs on the plains of extreme eastern Colorado, but has not yet been reported.]

Page 104. 566. **Junco aikeni.** WHITE-WINGED JUNCO.

Page 105. 567b. **Junco hyemalis connectens.** SHUFELDT'S JUNCO.

Both taken at Breckenridge in migration.

Page 105. Add. 567.1. **Junco montanus.** MONTANA JUNCO.

This new form was recently described by Mr. Ridgway, who writes: "In our somewhat extensive series of *Junco montanus*, I find only one specimen from Colorado. This is a female, No. 109,943, U. S. N. M., collected at Pueblo, October 29, 1886, by C. W. Beckham. There are several examples from New Mexico and Arizona; all fall and winter birds." Mr. C. E. Aiken took this form at Ramah in February, 1899. He also has several specimens in his collection taken March 2, March 27 and October 25. The species therefore stands in the Colorado list as: Winter visitant, not uncommon; arrives the last of October and remains until late in March.

Page 105. 569. **Junco caniceps.** GRAY-HEADED JUNCO.

Breeds abundantly at Breckenridge, and in 1898 one nested under the eaves of Mr. Carter's house. A very late record for the plains was one taken by Mr. C. E. Aiken at Limon on May 25, 1899.

Page 106. 573a. **Amphispiza bilineata deserticola.** DESERT SPARROW.

This is the name now given to the bird that was formerly entered as the Black-throated Sparrow. Mr. P. L. Jones reports finding a nest with young near Canon City in 1888. This is the only time he saw the bird there in five years' residence.

Page 106. Add. [578. **Peucaea cassini.** CASSIN'S SPARROW.

"Central and western Kansas, southward and westward through Texas, New Mexico, Arizona and southern Nevada."—(A. O. U.) It would be difficult

to have any bird a rather common summer resident over the western half of Kansas, also common in New Mexico at the same season, and not have it occur in southeastern Colorado. But up to the present time no one has found it in this State.]

Page 107. 581b. **Melospiza fasciata montana.** MOUNTAIN SONG SPARROW.

Mr. Carter has taken it at Breckenridge only in migration. On the Blue river, at 7,500 feet, he took the nest and eggs July 5, 1877. He has never known it to nest above 8,000 feet.

Page 107. 583. **Melospiza lincolni.** LINCOLN'S SPARROW.  
Breeds at Breckenridge.

Page 107. 585c. **Passerella iliaca schistacea.** SLATE-COLORED SPARROW.

A mounted specimen in Mr. Carter's collection was taken near the mouth of the Blue river in Grand county, July 5, 1877, at nearly 7,000 feet. This is one more summer record for Colorado, and the highest altitude at which it has yet been reported.

Page 108. 588a. **Pipilo maculatus megalonyx.** SPURRED TOWHEE.

Mr. Blanchard has found some eggs at Boulder as early as May 10. Mr. Carter has found it breeding nearly to Breckenridge.

Page 108. 592.1. **Oreospiza chlorura.** GREEN-TAILED TOWHEE.

This is the new number given to this species, hence it should come just after Abert's Towhee.

Mr. Carter has found it breeding as far up as Dillon, at 9,000 feet.

Page 108. 596. **Zamelodia melanocephala.** BLACK-HEADED GROSBEAK.

Found by Mr. Carter breeding in Middle Park and on the Blue river up to 8,500 feet.

Page 109. 597a. **Guiraca cærulea lazula.** WESTERN BLUE GROSBEAK.

Page 109. 598. **Cyanospiza cyanea.** INDIGO BUNTING.

Mr. Wm. Link saw several at Fort Collins about the middle of May, 1900. One was taken and is now mounted. They stayed round the premises for several days, and Mr. Link thought he saw three of them again in his yard May 30. This is the third record for Colorado.



Page 109. 599. **Cyanospiza amoena.** LAZULI BUNTING.

Mr. Carter has not found it breeding higher than Middle Park.

Page 109. 604. **Spiza americana.** DICKCISSEL.

Mr. P. L. Jones of Beulah, reports finding the nest and eggs at Canon City in 1890. He saw the birds there during several years.

Page 109. 605. **Calamospiza melanocorys.** LARK BUNTING.

Found by Mr. Carter breeding at Dillon at 9,000 feet.

Page 110. 607. **Piranga ludoviciana.** LOUISIANA TANAGER.  
Breeds at Breckenridge.

Page 110. 608. **Piranga erythromelas.** SCARLET TANAGER.

One was reported to Mr. C. E. Aiken as seen at Limon in May, 1899.

Page 110. 611. **Progne subis.** PURPLE MARTIN.

Miss Myra Eggleston writes that Purple Martins are common at Grand Junction, but do not breed in town, preferring the banks of the river not far distant.

Page 110. 612. **Petrochelidon lunifrons.** CLIFF SWALLOW.

Page 111. 613. **Hirundo erythrogaster.** BARN SWALLOW.

Page 111. 614. **Tachycineta bicolor.** TREE SWALLOW.

Page 111. 615. **Tachycineta thalassina.** VIOLET-GREEN SWALLOW.

All these four breed in the mountains, though Mr. Carter has never seen the Tree Swallow breeding quite as high as Breckenridge, where the others are common.

Page 111. 618. **Ampelis garrulus.** BOHEMIAN WAXWING.

Seen at Breckenridge in winter.

Page 112. 621. **Lanius borealis.** NORTHERN SHRIKE.

Page 112. 622a. **Lanius ludovicianus excubitorides.** WHITE-RUMPED SHRIKE.

Both of these have been taken by Mr. Carter, either at or near Breckenridge.

Page 112. 624. **Vireo olivaceus.** RED-EYED VIREO.

The Bond collection at Cheyenne, Wyoming, contains a specimen taken there May 26, 1889, and Rev. F. N. White saw one there May 20, 1899.

Page 112. 627. **Vireo gilvus.** WARBLING VIREO.

Page 112. 629b. **Vireo solitarius plumbeus.** PLUMBEOUS VIREO.

Both these species breed at Breckenridge.

Page 112. Add. [630. **Vireo atricapillus.** BLACK-CAPPED VIREO.

"Central and western Texas, from the Rio Grande north to southwestern Kansas."—(A. O. U.) Should be found along the Cimarron river in southeastern Colorado.]

Page 112. Add. [631. **Vireo noveboracensis.** WHITE-EYED VIREO.

"Eastern United States, west to the Rocky Mountains."—(A. O. U.) This should include Colorado, but there is no record known to the present writer from this State.]

Page 112. Add. [633. **Vireo bellii.** BELL'S VIREO.

"Upper Mississippi valley and Great Plains."—(A. O. U.) "From Illinois and Minnesota west to the eastern base of the Rocky Mountains."—(Goss.) "Inhabits the middle parts of the United States, from Illinois and Minnesota west to the foothills."—(Lantz.)

One would suppose from these statements that it was not uncommon in Colorado, and possibly it is not, but there is no record for it here up to the present time.]

Page 113. 644. **Helminthophila virginiae.** VIRGINIA'S WARBLER.

Taken by Mr. Carter in both Middle and South Parks, where it breeds. Also taken by Mr. C. E. Aiken in May, 1899, at Limon, far out on the plains.

Page 113. 647. **Helminthophila peregrina.** TENNESSEE WARBLER.

There is one in the Bond collection, taken at Cheyenne, Wyoming, May 24, 1888.

One was taken by Mr. C. E. Aiken near Limon in May, 1899.

Page 114. 648. **Compsothlypis americana.** PARULA WARBLER.

The known northern range of this species is extended nearly two hundred miles by a specimen taken at Cheyenne, Wyoming, May 30, 1888, and now in the Bond collection.

Page 114. 652. **Dendroica aestiva.** YELLOW WARBLER.

Breeds in Middle Park and at Breckenridge.



Page 115. 656. **Dendroica auduboni.** AUDUBON'S WARBLER.  
Breeds at Breckenridge.

Page 115. 661. **Dendroica striata.** BLACK-POLL WARBLER.  
There is a specimen taken by Mr. Bond at Cheyenne, Wyoming, May 11, 1888, and Rev. F. N. White saw one there May 15, 1899.

Page 116. 668. **Dendroica townsendi.** TOWNSEND'S WARBLER.

A young male was taken at Cheyenne, Wyoming, and is now in the Bond collection.

Page 116. 674. **Seiurus aurocapillus.** OVEN-BIRD.

On June 5, 1898, Mr. C. E. Aiken shot at Ramah a female with ovaries so extended that there seemed no doubt of its breeding. On the strength of this record the bird is included among the Colorado breeders.

Page 116. 675a. **Seiurus noveboracensis notabilis.** GRINNELL'S WATER-THRUSH.

One in the Bond collection at Cheyenne, Wyoming.

Page 116. Add. 678. **Geothlypis agilis.** CONNECTICUT WARBLER.

Migratory; rare or accidental. The first and only record for Colorado is the one taken by Mr. C. E. Aiken, who writes:

"On May 24, 1899, I shot a male in a clump of willows bordering a water hole at Lake, Lincoln county, about one hundred miles northeast of Colorado Springs. This unexpected capture adds an interesting eastern bird to the fauna of Colorado, and extends the known range of the species several hundred miles to the westward."

Page 116. 680. **Geothlypis tolmiei.** MACGILLIVRAY'S WARBLER.

Breeds in Middle Park, according to Mr. Carter.

Page 117. Add. 681. **Geothlypis trichas.** MARYLAND YELLOW-THROAT.

One taken by Mr. C. E. Aiken at Colorado Springs, May 31, 1898, and identified by Mr. Ridgway. This is the eastern form, rarely coming west to the plains.

Page 117. 681a. **Geothlypis trichas occidentalis.** WESTERN YELLOW-THROAT.

One was seen May 8, 1898, by Mr. L. B. Gilmore at Sweet-water Lake at 8,000 feet.

Mr. Carter has found it breeding at Dillon at 9,000 feet.

Page 117. 685. **Wilsonia pusilla.** WILSON'S WARBLER.

Page 117. 685a. **Wilsonia pusilla pileolata.** PILEOLATED WARBLER.

Its occurrence in Colorado will now be changed to: Summer resident; not uncommon.

There is in the Carter collection a specimen, quite typical, that was taken with nest and eggs at the eastern side of South Park, July 3, 1878. Mr. C. E. Aiken believes that this form is fully as common in Colorado as the eastern *pusilla*.

Page 118. Add. 686. **Wilsonia canadensis.** CANADIAN WARBLER.

Migratory; rare or accidental. Added to the Colorado list by Mr. C. E. Aiken in the following note:

"The range of this species is extended westward nearly to the Rocky Mountain range by my capture of a male at Lake, Lincoln county, May 23, 1899.

Page 118. 678. **Setophaga ruticilla.** AMERICAN REDSTART.

Breeds in Middle Park. The foregoing records show that of the twenty-nine Warblers known to occur in Colorado, but three have been taken breeding at Breckenridge by Mr. Carter, showing how few of these birds go up into the high mountains.

There are twenty-five Warblers given in the last edition of the A. O. U. Check List whose range is said to be "Eastern United States" or "Eastern United States to the Plains," thus not including Colorado in their habitat. These have all been taken in Kansas, and eleven of them have been found in Colorado. Since these eleven include several that would have been considered as little likely as any to be found in this State, we may expect that sooner or later most of the other fourteen will be noted in Colorado. Those not yet found here are *Protonotaria citrea*, *Helmitherus vermivorus*, *Helminthophila pinus*, *Helminthophila ruficapilla*, *Dendroica pensylvanica*, *Dendroica Blackburnia*, *Dendroica dominica albilora*, *Dendroica virens*, *Dendroica vigorsii*, *Dendroica discolor*, *Seiurus motacilla*, *Geothlypis formosa*, *Geothlypis philadelphia*, and *Wilsonia mitrata*.



Page 118. Add. [700. **Anthus spragueii**. SPRAGUE'S PIPIT.

It seems strange that there is no record of this bird for Colorado, when there are three specimens in the Bond collection, taken at Cheyenne, Wyoming, April 24, 1888, and it was undoubtedly seen there by Rev. F. N. White, April 29, 1899. It is unreasonable not to suppose that these birds crossed Colorado to reach Cheyenne. Moreover they are said to be: "Rare in eastern Kansas, common in the western part of the State."—(Lantz.) It is practically certain then that they occur in eastern Colorado, and that before long some one will find them there.]

Page 118. 701. **Cinclus mexicanus**. AMERICAN DIPPER.

Mr. Blanchard has taken nests on Boulder Creek four miles above Boulder at about 5,500. Two sets were taken, May 6 and May 12, 1898. All the sets he ever found in that locality were between May 1 and May 15. It is thus evident that these birds at the lower altitude nested earlier than is customary at the usual altitude.

Mr. Carter found the Dipper breeding at Breckenridge.

Page 119. 702. **Oroscoptes montanus**. SAGE THRASHER.

Mr. Carter has found them at Dillon at 9,000 feet, but does not know of their breeding higher than Middle Park.

Page 119. 703. **Mimus polyglottos**. MOCKINGBIRD.

The present writer saw two at the San Luis Lakes and one at La Jara on June 17 and 18, 1898. Mr. D. E. Newcomb of La Jara says that some years he sees them several times; other years they are absent. Miss Myra Eggleston reports them as breeding at Grand Junction. This completes the record for the whole southern half of Colorado, from Kansas to Utah.

There is one in the Carter collection, taken at Breckenridge August 12, 1891. This is 1,500 feet higher than any previous record, and was undoubtedly a wanderer.

Page 119. 704. **Galeoscoptes carolinensis**. CATBIRD.

The date of nesting should read the latter part of May, instead of June.

Mr. Carter reports it as a rare breeder in Middle Park.

Page 120. 715. **Salpinctes obsoletus**. ROCK WREN.

Breeds at Breckenridge.

Page 120. 719b. **Thryomanes bewickii leucogaster**. BAIRD'S WREN.

Page 120. 721b. **Troglodytes aedon aztecus**. WESTERN HOUSE WREN.

Breeds at Breckenridge.

Page 121. 722. **Anorthura hiemalis.** WINTER WREN.

One taken by Dr. W. H. Bergtold in Denver, July 8, 1896. This is the lowest summer record.

Page 121. Add. [724. **Cistothorus stellaris.** SHORT-BILLED MARSH WREN.

One in the Bond collection, taken at Cheyenne, Wyoming, April 14, 1889.]

Page 121. 725c. **Cistothorus palustris plesius.** WESTERN MARSH WREN.

Known by Mr. Carter to breed in South Park.

Page 121. 726b. **Certhia familiaris montana.** ROCKY MOUNTAIN CREEPER.

Page 122. 727a. **Sitta carolinensis aculeata.** SLENDER-BILLED NUTHATCH.

Page 122. 728. **Sitta canadensis.** RED-BREASTED NUTHATCH.

Page 122. 730. **Sitta pygmæa.** PYGMY NUTHATCH.

Page 122. 735a. **Parus atricapillus septentrionalis.** LONG-TAILED CHICKADEE.

Page 123. 738. **Parus gambeli.** MOUNTAIN CHICKADEE.

These last six species are all common birds of the mountains and have all been taken by Mr. Carter at Breckenridge. The present writer found the Mountain Chickadee common and evidently breeding at Trinidad, June 15, 1898. This is only 6,000 feet, much lower than this species usually nests.

Page 123. 744. **Psaltiriparus plumbeus.** LEAD-COLORED BUSH-TIT.

During the summer of 1897 Capt. D. P. Ingraham took three sets of eggs near Beulah. Mr. C. E. Aiken has seen them occasionally in large flocks in winter in the foothills northeast of Canon City. He took a nest and five fresh eggs there May 9, 1876. Mr. Wm. Cross took the nest and six eggs at Glenwood Springs during the summer of 1898.

Page 123. 749. **Regulus calendula.** RUBY-CROWNED KINGLET.

A nest and seven eggs have been presented to the State Historical and Natural History Society of Denver, that were taken by Mr. Evan Lewis at Boswell, near Twin Lakes, June 12, 1898, at an elevation of 11,000 feet.

The lowest Mr. Carter has ever known of their nesting was at 7,000 feet, in Middle Park.



Page 124. 754. **Myadestes townsendii.** TOWNSEND'S SOLITAIRE.

Breeds above timber line near Breckenridge.

Page 124. 756a. **Hylocichla fuscescens salicicola.** WILLOW THRUSH.

Page 124. 758a. **Hylocichla ustulata swainsoni.** OLIVE-BACKED THRUSH.

Page 125. 759. **Hylocichla aonalaschkæ.** DWARF HERMIT THRUSH.

One taken by Mr. C. E. Aiken during the season of 1898, and three during the spring of 1899.

Page 125. 759a. **Hylocichla aonalaschkæ auduboni.** AUDUBON'S HERMIT THRUSH.

Breeds at Breckenridge.

Page 125. 759b. **Hylocichla aonalaschkæ pallasii.** HERMIT THRUSH.

Page 126. 761a. **Merula migratoria propinqua.** WESTERN ROBIN.

Breeds at Breckenridge.

Page 126. 766. **Sialia sialis.** BLUEBIRD.

Mr. Bond says that the Eastern Bluebird is a regular summer visitant to the City Park in Cheyenne, Wyoming.

Page 126. 767a. **Sialia mexicana bairdi.** CHESTNUT-BACKED BLUEBIRD.

Mr. Carter has found it breeding in South Park, but never as high as Breckenridge.

Page 126. 768. **Sialia arctica.** MOUNTAIN BLUEBIRD.

Breeds at Breckenridge.

Page 148. B. *Species that breed on the plains.* Omit  
Helminthophila peregrina.

Page 149. 7. **Migrants.** Omit  
Helminthophila peregrina.

Page 155. 8. **Gavia adamsii.** YELLOW-BILLED LOON.

Page 156. 160. **Somateria dresseri.** AMERICAN EIDER.

Further research has shown that the specimen mentioned at the capitol at Denver was taken outside of Colorado.

Page 162. 418a. **Phalænoptilus nuttallii nitidus.** FROSTED POOR WILL.

The two specimens taken by Mr. Aiken have been later identified as true *nuttallii*.

Page 167. 595. **Zamelodia ludoviciana.** ROSE BREASTED GROSBEAK.

Page 168. 647. **Helminthophila peregrina.** TENNESSEE WARBLER.

This is now withdrawn from the list of Colorado breeders since Mr. Aiken has satisfied himself that the record is a mis-identification for Virginia's Warbler.

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## ADDENDUM.

While the last pages of this bulletin are passing through the press, the *Auk* for July, 1900, is received, necessitating the following addition:

Page 186. Add. Aiken, C. E. Seven New Birds for Colorado. *Auk*, XVII. 1900, p. 298.

Adds to the Colorado list, *Gavia arctica*, *Ardea egretta*, *Syrnium nebulosum*, *Astragalinus tristis pallidus*, *Geothlypis agilis*, *Geothlypis trichas*, *Wilsonia canadensis*.

The records of these birds for Colorado have been given in this bulletin, but since the article in the *Auk* was published first, it becomes the first record of these birds for Colorado, instead of this bulletin.



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## FARM NOTES

Alfalfa, Corn, Potatoes and Sugar Beets

—BY—

W. W. COOKE

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Bulletin No. 56, being a technical bulletin, is printed in a small edition and is not sent to the general mailing list. It will be sent to individuals upon request.

The bulletin is a second appendix to No. 37 on "The Birds of Colorado," by Professor W. W. Cooke, of which No. 44 was the first appendix. It gives lists of birds that have been found in Colorado, with localities where they have been found, and some notes.

Some who receive this bulletin may have a copy of No. 37 which they do not need, or are willing to spare for the benefit of others who have greater use for it. Requests come from many who have good reason to desire a copy, which the Station cannot supply. Send to the Station or address

THE DIRECTOR,  
Agricultural Experiment Station,  
Fort Collins, Colorado.





# FARM NOTES.

By W. W. COOKE.

The following bulletin contains the records of various tests that have been made on the college farm during the years 1894 to 1899. They are grouped under the following headings:

## I. Alfalfa.

- a*—Losses in cutting and curing.
- b*—Losses in the stack and in the barn.
- c*—Alfalfa ensilage.
- d*—Three methods of handling alfalfa.
- e*—Top-dressing alfalfa.
- f*—Moisture in green alfalfa.
- g*—Moisture in alfalfa hay.

## II. Corn.

- a*—Silo notes.
- b*—Seed corn from different altitudes and latitudes.
- c*—Variety tests of corn.
- d*—Number of stalks in a hill.
- e*—Missing hills in a corn field.

## III. Potatoes.

- a*—Alfalfa sod compared with old land.
- b*—Experiments with fertilizers.

## IV. Sugar Beets.

- a*—Subsoiling for sugar beets.
- b*—Sugar beets in Colorado in 1899.
  - 1. Time of planting.
  - 2. Distance between rows.
  - 3. Irrigating the seed.
  - 4. Variety tests.
  - 5. Summary.

## I. ALFALFA.

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### A—LOSSES IN CUTTING AND CURING.

It has long been known that there was some loss in making alfalfa hay. Part of this loss is chemical, arising from the fermentation of the hay when exposed to rains during the curing process. The rest of the loss is mechanical and consists of the breaking off of the leaves and smaller ends of the branches when the alfalfa is hauled after it becomes dry. To overcome the latter loss, so far as possible, it is customary to rake the alfalfa while it is yet far from dry, and, particularly, early in the morning while the dew still makes it damp and pliable. It is also cocked while still quite moist, and allowed to dry out slowly. Both these methods, while saving the mechanical losses, tend toward the increasing of the chemical losses through fermentation.

To ascertain the exact amount of these losses several experiments have been made in different years.

In the first set of tests, the field was divided into several long narrow strips. The whole field was cut at the same time, then every other strip was gathered up at once, weighed and three samples taken. The alternate plots were made into hay according to our usual methods. When fully cured this hay was brought to the barn, weighed and four samples taken. The weight of the first multiplied by the average composition of the samples gives the value of the alfalfa when cut; the weight of the hay when cured, multiplied by its average composition gives its value after curing. The supposition was made that the alfalfa left on the ground weighed the same and had the same composition as that gathered up. Since the number of plots was never less than ten and the size was quite large, it is probable that the error, if any, was quite small.

Three tests were made in this manner, and they illustrate the different conditions under which alfalfa hay is cured.

The first cutting was made May 28 and owing to several rains and considerable cloudy weather, it was not until June 12 that the hay was ready to go into the barn. This hay



had a hard time of it, but no worse than often happens to the first cutting of alfalfa in northern Colorado. The plots gathered up at once on May 28 yielded at the rate of 16,553 pounds of green alfalfa per acre, which contained 23.2 per cent of dry matter or 3,840 pounds of dry matter per acre. After the fifteen days of hardship the final hay secured weighed 3,302 pounds per acre, with 86.0 per cent of dry matter or 2,839 pounds of dry matter per acre. Thus, of the original 3,840 pounds of dry matter, but 2,839 pounds were saved, showing a loss of 1,001 pounds per acre or 26.1 per cent.

In the second test the alfalfa was cut June 21, raked and cocked June 23, and brought to the barn June 28, or seven days after cutting. The only moisture on this hay was a small rain and a mere sprinkle, both coming after the hay was in the cock, and neither enough so that the hay had to be opened up to dry. This case represents the ordinary good conditions of the first crop of alfalfa in Colorado. At the time of cutting the field yielded at the rate of 16,258 pounds of alfalfa per acre, containing 30.3 of dry matter or 4,926 pounds of dry matter per acre. The hay put in the barn weighed 4,900 pounds per acre and was very dry, testing 90.3 per cent dry matter or 4,425 pounds of dry matter per acre. In this case, of the original 4,926 pounds of dry matter, 4,425 pounds were saved; a loss of 501 pounds per acre or a loss of 10.2 per cent.

The third trial was made in September, under perfect weather conditions, the hay coming to the barn without having had a drop of moisture fall on it. The crop was the heaviest ever cut on the College farm in the fall. The green weight was 13,133 pounds per acre, containing 38.0 per cent dry matter, or 4,990 pounds dry matter per acre. This field produced, in the whole season, a little over seven and a half tons of hay per acre. When the experimental hay was put in the stack it weighed 5,097 pounds per acre and contained 93.0 per cent dry matter or 4,740 pounds of dry matter per acre. So, in this third trial there was a loss of but 5.1 per cent of the value of the hay in curing and stacking.

The other method used for making a test of this same point was to cut the field and at once gather up the alfalfa from sixteen different plots scattered over the field, each plot being twenty feet long and the width of the mower swath. It was considered that these sixteen plots of over a thousand square feet would represent the average of the field.

In the first test the alfalfa was cut June 8, raked June 12, cocked the 14th and taken to the barn June 16. The

weather on June 9 and 10 was cloudy with some showers, but at this time the alfalfa had not yet dried much and it was but little injured by the rain. It showed a total loss of 9.0 per cent of value in the curing and gathering.

The next sample was cut June 15, raked June 17, cocked June 18 and gotten in the same day; all without a drop of rain. It also showed 9.0 per cent loss.

The third lot was cut June 22, raked and cocked June 24. That night a quarter of an inch of rain fell and the next day was showery. The hay was opened up, turned and recocked June 26 and taken to the barn June 28. It showed a loss of 13.0 per cent of dry matter.

Another field was cut June 15, raked June 18, cocked June 19 and gotten in June 22. The weather was perfect and the hay showed 11.0 per cent of loss. Still another field cut at about the same time and under the best of conditions, showed 10.0 per cent loss.

We thus have eight tests of the losses in curing and gathering alfalfa. They vary from 5.1 per cent to 26.1 per cent, with an average of 11.7 per cent.

It is probable that this average is not far from the real average of the losses on the alfalfa in Colorado that does not suffer any hard rain. The first test with a loss of 26.1 per cent, shows what may easily happen under bad conditions.

It is specially to be noted that the hay which was made in perfect weather shows about the same loss as that which had cloudy weather and light showers. The hay that dried most rapidly became so brittle that the mechanical losses of leaves and stem were fully equal to the losses by fermentation during the damper weather.

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#### B—LOSSES OF ALFALFA IN THE STACK AND IN THE BARN.

A test was made to determine how much of its feeding value was lost by alfalfa hay after it was put in the stack and how much of that loss could be saved by putting the hay in a barn.

A field of alfalfa was all cut the same day, handled alike until made into well cured hay, then it was hauled and each two loads put alternately in the stack and in the barn. The stack was divided by slats into four layers and the hay in the barn into four corresponding layers. The hay in each layer was weighed separately and duplicate samples taken for analysis. This hay was the first cutting and was put in the stack June 15. It remained in the stack eight months and on



February 16 all the layers of the stack and in the barn were again weighed and sampled. The stack was about the same height and width of the usual alfalfa stack in Colorado and its being shorter than the average scarcely affects the results.

As would be expected the top and bottom layers of the stack suffer more loss than the middle layers. The top layer lost, about five per cent of its weight in spoiled hay and the bottom layer about the same per cent of waste hay that was so injured by the dampness of the ground as to be unsalable.

All the layers lost considerably in weight as follows:

## LOSS OF WEIGHT IN STACK.

| Layer.       | Weight as put in<br>June 15. | Weight when taken<br>out Feb. 12. | Per cent of loss<br>in weight. |
|--------------|------------------------------|-----------------------------------|--------------------------------|
| Bottom.....  | 5048                         | 4160                              | 17.6                           |
| Second.....  | 4906                         | 4244                              | 13.5                           |
| Third.....   | 4754                         | 3946                              | 17.0                           |
| Top.....     | 4664                         | 3554                              | 23.8                           |
| Average..... | 4843                         | 3986                              | 17.7                           |

This loss, however, is largely due to the drying out of the water in the hay. As put up the hay averaged 18.9 per cent of water; as taken out this had dried to but 11.1 per cent of water. The changes that took place in the dry matter give these figures:

## LOSS OF DRY MATTER IN STACK.

| Layer.       | Dry Matter as put<br>in June 15. | Dry matter when<br>taken out Feb. 12. | Per cent of loss<br>in dry matter. |
|--------------|----------------------------------|---------------------------------------|------------------------------------|
| Bottom.....  | 4069                             | 3593                                  | 11.7                               |
| Second.....  | 4031                             | 3818                                  | 5.3                                |
| Third.....   | 4030                             | 3550                                  | 11.9                               |
| Top.....     | 3585                             | 3197                                  | 10.8                               |
| Average..... | 3929                             | 3539                                  | 10.0                               |

This latter table does not show the loss in real feeding value, for both the top and the bottom layers had some hay that could not be used for feeding. If the amount of this spoiled hay is subtracted, it leaves the following as the losses of feeding value:

## LOSS OF FEEDING VALUE IN STACK.

| Layer.       | Feeding value as put<br>in June 15. | Feeding value when<br>taken out Feb. 12. | Per cent of loss<br>in feeding value. |
|--------------|-------------------------------------|------------------------------------------|---------------------------------------|
| Bottom.....  | 4069                                | 3390                                     | 16.8                                  |
| Second.....  | 4031                                | 3818                                     | 5.3                                   |
| Third.....   | 4030                                | 3550                                     | 11.9                                  |
| Top.....     | 3585                                | 2997                                     | 16.1                                  |
| Average..... | 3929                                | 3439                                     | 12.4                                  |

The results show that for every hundred pounds of hay

put into the stack 82.3 pounds were taken out and for every hundred pounds of feeding value in the hay as put in the stack 12.4 pounds were lost and 87.6 pounds were saved. The loss is one-eighth; that is, for every eight tons of feeding value in the original hay, seven tons are saved and one lost.

Chemical analyses were made of the hay as put into the middle layers of the stack and as taken out. A comparison of the two analyses shows what changes took place in the hay during process of curing in the stack.

COMPOSITION OF THE STACKED HAY.

|                            | As put in<br>June 15. | As taken out<br>February 12. |
|----------------------------|-----------------------|------------------------------|
| Water.....                 | 16.6                  | 10.0                         |
| Dry Matter.....            | 83.4                  | 90.0                         |
| Analysis of Dry Matter—    |                       |                              |
| Ash.....                   | 9.91                  | 11.84                        |
| Ether Extract.....         | 1.25                  | 1.34                         |
| Crude Protein.....         | 15.07                 | 14.74                        |
| Crude Fiber.....           | 36.97                 | 38.62                        |
| Nitrogen-free Extract..... | 36.79                 | 33.46                        |

The analysis taken in connection with the weights shows that the following losses of food ingredients took place in these middle layers of the stack.

LOSS OF FOOD INGREDIENTS IN THE STACK.

|                            | As put in<br>June 15. | As taken out<br>February 12. | Per cent<br>of loss. |
|----------------------------|-----------------------|------------------------------|----------------------|
| Ether Extract .....        | 101                   | 99                           | 2.0                  |
| Crude Protein.....         | 1214                  | 1086                         | 10.5                 |
| Crude Fiber.....           | 2978                  | 2845                         | 4.4                  |
| Nitrogen-free Extract..... | 2964                  | 2465                         | 16.8                 |
| Total.....                 | 7257                  | 6495                         | 10.5                 |

Samples were also taken and analyzed of the load from the top of the stack and from the bottom. The analyses are given below in comparison with the composition of the alfalfa when put in the stack.

|                            | Original. | Top of stack. | Bottom of stack |
|----------------------------|-----------|---------------|-----------------|
| Ash.....                   | 9.91      | 11.64         | 12.18           |
| Ether Extract.....         | 1.25      | 1.47          | 1.77            |
| Crude Protein.....         | 15.07     | 15.94         | 17.04           |
| Crude Fiber.....           | 36.97     | 38.82         | 36.84           |
| Nitrogen-free Extract..... | 36.79     | 32.13         | 32.75           |

In the top of the stack the loss falls on both the protein and the extract matter, while at the bottom the loss is almost confined to the extract matter and crude fiber. In both cases the loss of carbohydrates is greater than in the middle layers.

The losses on the hay that was put in the barn show quite a different result:



## LOSS OF WEIGHT IN BARN.

| Layer        | Weight as put<br>in June 15. | Weight when taken<br>out February 12. | Per cent of loss<br>in weight. |
|--------------|------------------------------|---------------------------------------|--------------------------------|
| Bottom.....  | 3778                         | 3480                                  | 7.9                            |
| Second.....  | 4752                         | 4091                                  | 13.8                           |
| Third.....   | 4696                         | 4103                                  | 12.6                           |
| Top.....     | 4236                         | 3663                                  | 13.5                           |
| Average..... | 4365                         | 3834                                  | 12.2                           |

Judging by these figures alone one would think that the losses in the barn had been nearly as much as in the stack. A study of the amounts of dry matter shows that these losses are almost entirely losses in weight of water. The hay as put in the barn contained 20.8 per cent of water; when taken out it contained but 12.1 per cent of water. There were 13,804 pounds of dry matter put into the barn and 13,478 pounds of dry matter taken out, being a loss of but 2.5 per cent. Since there was no waste hay this 2.5 per cent represents also the loss in feeding value in the barn.

The final averages show 12.4 per cent of feeding value lost in the stack, while but 2.5 per cent of feeding value was lost from the hay that was put in the barn. This shows a difference of ten per cent in favor of the barn.

In other words *nine tons of hay put in the barn will feed as much stock as ten tons put in the stack.*

It should be remembered that while these results indicate average conditions for the barn, they represent rather better than average figures for stacks of the first cutting of alfalfa in Northern Colorado. The stack under experiment was put up in good shape and had a chance to settle well before much rain fell upon it, while the season was in general favorable for hay in stack. These figures may be said to represent the least losses that one should expect with the first cutting. Had the same test been made in 1895 a very different story would result. That year at least one-third of the dry matter in the stack was lost. We made an extended test of the feeding value of this injured stack hay as compared with similar hay from the barn. It was found that the sheep eating the two lots of hay made exactly the same gain for the entire five months of the test, but for every two tons of hay from the barn we had to draw three tons from the stack, and this was in addition to the large amounts of worthless hay on the tops and bottoms of the stack. In that year therefore 4.4 tons of hay put into the barn yielded as much feed as 10 tons in the stack.

Of course this is an extreme case, but the average loss of all years for Northern Colorado is probably not less than a

fifth, that is, eight tons of hay in the barn is equal to ten tons of hay in the stack.

It may be asked why the farmers do not build barns for their hay and save these large losses. The answer is easily given. Barns are expensive to build and keep in repair; the labor of putting hay into the barn and feeding it to any stock, except milch cows, is considerably more than to handle the hay by stacking. At present low prices of hay, the two items above more than equal the losses of hay in the stack. It seems probable that at six dollars a ton the gains will about equal the losses, and at above that price one could not afford to stack the first cutting.

All the above calculations are for the first cutting and for Northern Colorado. The losses with the second cutting are much less, while the the third cutting has practically no loss.

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#### C—ALFALFA ENSILAGE.

Some tests were carefully made on a small scale to see what losses might be expected in making ensilage of alfalfa. One test was made with the alfalfa put in whole as cut in the field, the other with the alfalfa cut to quarter inch pieces as we cut our corn for ensilage. The whole alfalfa showed a spoiled layer three inches thick on the top and an inch layer around the side nearly all the way down. The ensilage of the bottom and middle was excellent and was greedily eaten by the cows and calves. Its loss in the total weight was 10.7 per cent, but its loss in feeding value was probably a little larger.

The other silo was filled with cut alfalfa. The next day the silo was covered with two thicknesses of building paper and one of boards and weighted with stone to about fifty-five pounds per square foot. When covered the ensilage was hotter than the hand could bear. Two days later the temperature had fallen to 83° F. and in two days more it had fallen to that of the air. The ensilage shrank and settled a good deal. When put in it contained 33.0 per cent of dry matter. On opening the silo showed two inches of spoiled ensilage on top and half an inch on the sides. The spoiled ensilage was 7.3 per cent of the total weight. The loss in dry matter was approximately ten per cent.

It is fair to presume that with a good tight silo, well made ensilage from cut alfalfa should not make a larger loss than was here given in our small experimental silo, or about ten per cent of its feeding value. To make good



ensilage from whole alfalfa is a much harder proposition. It requires that the alfalfa be quite green; that the silo be both tight and deep; that the alfalfa be thrown into the silo in small forkfuls and carefully tramped and that it be weighted by four to six feet of some heavy, tight packing material like cut corn fodder. If the alfalfa is put up in the middle of summer in clear, bright weather, it must be raked and loaded as fast as cut. One lot we tried was too dry for ensilage two hours after it was cut.

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#### D—THREE METHODS OF HANDLING ALFALFA.

The preceding pages have given the losses that may be expected from handling alfalfa in the stack, in the barn and in the form of ensilage. Combining the losses in curing and gathering to those found in the stack and the barn, we can say that under the best of ordinary conditions, for every 100 pounds of feeding value as it exists in the green alfalfa at the time it is cut by the mower, 77 pounds will be saved if the hay is well cured and put in a stack under good conditions; 86 pounds will be saved if put in the barn, and 90 pounds can be expected if made into first-class ensilage. The cost of the ensilage is so much more than handling the alfalfa as hay that as between the silo and the barn there can be no question unless it is shown that the dry matter of the alfalfa ensilage has a higher feeding value, pound for pound, than that of the dry hay. In the comparison of the ensilage and the stacked hay, the principal advantage of the ensilage must lie in the fact that the alfalfa can be put in the silo, even under bad conditions of weather at time of cutting, and that once siloed it is safe from the worst weather.

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#### E—TOP-DRESSING ALFALFA.

A field which had been in alfalfa three years was divided into five equal plots. The first, third and fifth were left as checks. The second plot was fertilized at the rate of sixty loads to the acre of fine, well rotted sheep manure. The fourth plot received half as heavy a top-dressing. The manure was spread on in the winter and after the alfalfa started in the spring, it was run over with a smoothing harrow to break up the manure fine and allow the alfalfa shoots a good chance to grow.

When the field was ready for the first cutting the eye

could detect a difference between the plots. Those which had been manured were a darker green, the stems were larger, taller and more succulent, but they did not seem to be so numerous as on the untreated plots. The whole field was cut the same day and the hay on each plot was hauled the same day.

## FIRST CUTTING.

| Plot.           | Weight of hay. | Per cent of dry matter. | Weight of dry matter per plot. |
|-----------------|----------------|-------------------------|--------------------------------|
| 1               | 3100           | 88.7                    | 2750                           |
| 2               | 3212           | 81.3                    | 2611                           |
| 3               | 3080           | 88.9                    | 2738                           |
| 4               | 3112           | 88.5                    | 2764                           |
| 5               | 3172           | 89.3                    | 2838                           |
| Average 1, 3, 5 | 3117           | 88.9                    | 2771                           |
| Average 2, 4,   | 3162           | 84.9                    | 2685                           |

## SECOND CUTTING.

|                 |      |      |      |
|-----------------|------|------|------|
| 1               | 1978 | 81.9 | 1609 |
| 2               | 2518 | 79.8 | 2009 |
| 3               | 1720 | 82.8 | 1424 |
| 4               | 1920 | 81.0 | 1555 |
| 5               | 1842 | 78.9 | 1453 |
| Average 1, 3, 5 | 1847 | 81.2 | 1500 |
| Average 2, 4,   |      |      |      |

## THIRD CUTTING.

|                 |      |      |      |
|-----------------|------|------|------|
| 1               | 1100 | 83.2 | 915  |
| 2               | 1340 | 85.9 | 1151 |
| 3               | 970  | 88.7 | 860  |
| 4               | 1010 | 88.5 | 894  |
| 5               | 890  | 86.2 | 767  |
| Average 1, 3, 5 | 987  | 86.0 | 849  |
| Average 2, 4,   | 1175 | 86.0 | 1010 |

## TOTAL CROP FOR THE YEAR.

|                                    |      |      |      |
|------------------------------------|------|------|------|
| 1                                  | 6178 | 85.4 | 5274 |
| 2                                  | 7070 | 81.3 | 5771 |
| 3                                  | 5770 | 87.0 | 5022 |
| 4                                  | 6042 | 86.3 | 5213 |
| 5                                  | 5884 | 85.9 | 5058 |
| Average 1, 3, 5                    | 5944 | 86.1 | 5118 |
| Average 2, 4,                      | 6556 | 83.8 | 5492 |
| Difference in favor of fertilizing | 612  |      | 374  |
| Percentage Difference              | 10.3 |      | 7.3  |

## CROP FOR THE SECOND YEAR.

| Plot.                              | First Cutting. | Second Cutting. | Third Cutting. | Total Crop. |
|------------------------------------|----------------|-----------------|----------------|-------------|
| 1                                  | 2240           | 1900            | 1240           | 5380        |
| 2                                  | 2490           | 1908            | 1394           | 5792        |
| 3                                  | 2000           | 1546            | 1158           | 4704        |
| 4                                  | 2170           | 1856            | 1458           | 5484        |
| 5                                  | 2170           | 1820            | 1458           | 5448        |
| Average 1, 3, 5                    | 2137           | 1755            | 1285           | 5177        |
| Average 2, 4,                      | 2330           | 1882            | 1426           | 5638        |
| Difference in favor of fertilizing |                |                 |                | 461         |
| Percentage difference              |                |                 |                | 8.9         |



In both years the application of the fertilizer has apparently had a beneficial effect, but the result is not at all commensurate to the expense. Considering the manure itself as having no value, the mere hauling and spreading on the ground cost at the rate of more than thirty dollars per acre. The plots were close to an acre in size, so that the figures indicate a gain of about 500 pounds of hay or, at present prices, about a dollar's worth per acre.

No one could afford to top-dress alfalfa with the prospect of gaining only a dollar per acre per year. It seems probable that if it is desired to fertilize the land for alfalfa, that the land be plowed, the manure being turned to the bottom of the furrow, then the land cropped with corn and grain for one or two years and then seeded to alfalfa. We undertook to make this test, but the experiment was never completed.

In order to ascertain whether this heavy supply of plant food had made any difference in the chemical composition of the alfalfa, samples were analyzed of each of the cuttings of both the fertilized and unfertilized plots.

COMPOSITION OF DRY MATTER.

| Cutting                    | Ash   | Ether<br>Extract | Crude<br>Protein | Crude<br>Fiber | Nitro-<br>g'n-free<br>Extract | Total<br>Nitr'g'n | Phos-<br>phoric<br>Acid | Potash |
|----------------------------|-------|------------------|------------------|----------------|-------------------------------|-------------------|-------------------------|--------|
| First, fertilized.....     | 11.29 | 1.54             | 13.88            | 35.74          | 37.55                         | 2.22              | 0.59                    | 3.09   |
| Unfertilized.....          | 9.71  | 1.34             | 13.14            | 39.59          | 36.23                         | 1.93              | 0.46                    | 3.23   |
| Second, fertilized. ....   | 9.12  | 1.02             | 11.14            | 43.63          | 35.09                         | 1.78              | 0.43                    | 3.12   |
| Unfertilized.....          | 8.95  | 1.04             | 11.08            | 45.22          | 33.71                         | 1.78              | 0.36                    | 2.31   |
| Third, fertilized.....     | 10.99 | 1.19             | 14.58            | 36.74          | 36.51                         | 2.33              | 0.47                    | 2.75   |
| Unfertilized, .....        | 10.64 | 1.24             | 14.59            | 36.75          | 36.78                         | 2.33              | 0.42                    | 2.91   |
| Average fertilized.....    | 10.47 | 1.25             | 13.20            | 38.70          | 36.38                         | 2.11              | 0.51                    | 2.99   |
| Average unfertilized ..... | 9.77  | 1.21             | 12.97            | 40.52          | 35.59                         | 2.03              | 0.41                    | 2.83   |

The third cuttings are essentially duplicates. In the first and second cuttings the alfalfa from the fertilized plots has a higher feeding value and is richer in plant food. These differences are large enough so as to make it probable that the results are not accidental, but are due to real differences of composition caused by the application of the fertilizer.

**F—MOISTURE IN GREEN ALFALFA.**

The actual amount of water in alfalfa at the moment the mower knife cuts it, we have tested but little, as this has hardly any practical bearing, but we have made several tests of how much moisture it holds about an hour later, that is, in the condition it would be if put in the silo. One test the last week in May gave 76.8 per cent of water, or 23.2 per cent of dry matter. Four tests the third week in June gave 69.7, 67.0, 75.6, 72.8 with an average of 71.3 per cent of water, which is just about right for the best results in the silo.

A sample cut in September, in bright drying weather, was dried to 62.0 per cent water in an hour, too dry to be put in the silo, while a sample as actually put in the silo in October during cloudy weather was 74.0 per cent water.

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**G—MOISTURE IN ALFALFA HAY.**

Few farmers realize how much water there is in what they call dry hay.

It is impossible to dry out all the water from hay without resorting to artificial heat. Hay spread out in a thin layer in direct sunlight and sheltered from all rain and dew will finally dry out until a hundred pounds of hay contains only five pounds of water. This is as dry as it can be gotten without the use of a regular drying oven.

In Colorado "air dry" means with about ten per cent of water; that is, if hay is stored in a barn and sweats and dries out thoroughly, a hundred pounds will contain about ten pounds of water. Oats and wheat in the bin late in the winter contain about the same amount of water, while corn in the crib will contain by the next spring about the same ten per cent of water.

But the "well cured" hay, as usually put in the stack or the barn, is far from these conditions. In the course of our experiments we have had occasion to test the moisture of thirty-five samples of hay taken in different years and representing the three cuttings.

Three samples taken in June tested 23.2, 30.0 and 26.3 per cent of water, with an average of 26.5 per cent and they heated quite badly, becoming dusty and a little darkened. Seventeen samples that kept well tested 14.0, 13.0, 9.3, 11.2, 20.6, 22.7, 22.9, 17.1, 19.4, 17.8, 15.2, 23.1, 11.0, 10.8, 10.4, 18.4, 11.7 per cent with an average of 15.2 per cent of water. The driest of these with 9.3 per cent of water is too dry,



being so brittle as to lose too much in handling, while the wetter ones 20.0 per cent and above will probably contain some forkfuls that are too wet and will make the hay dusty. From 15 to 18 per cent of water is about right for the proper handling of the hay and its settling in the stack so as to shed rain. This means that the hay will lose about one-fourteenth of its weight of water in drying out in the stack, besides its loss from fermentation and washing.

The samples of hay from the second cutting contained 22.0, 24.0 and 24.0 per cent water and heated somewhat. Five samples contained 16.8, 18.9, 15.9, 17.7, 19.8 with an average of 17.8 per cent of water and all kept well.

Five samples of hay from the third cutting tested 15.5, 13.8, 11.0, 11.2, 13.5 averaging 13.0 per cent of water and all kept in excellent shape.

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## II. CORN.

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### A—SILO NOTES.

The very cheaply built silo described in a former bulletin of this station was filled with fodder corn. In one of the four compartments the top layer was composed of about a ton of corn, and the covering consisted of a layer of wet straw and then about four inches of wet dirt. The top layer was spoiled for a little over two inches. This and the covering make a weight for the second layer of about sixty pounds per square foot. This second layer contained 9997 pounds of corn fodder at the time of filling. When opened and fed out the last of December it weighed just a thousand pounds less, or a loss of ten per cent. The layer next under this shrank from 9721 pounds put in, to 9409 pounds taken out—a loss of but three per cent. The most expensive silo could not preserve corn with a less loss.

When the silo was filled the corn was separated into four layers by boards, and rods of known lengths were firmly attached to these board partitions, so that as the boards settled the thickness of the layers would be known from the height of the rods.

The silo was ten feet square and the bottom layer contained 6588 pounds of fodder corn cut into quarter inch pieces. When on top of this layer one more load had been

placed and well tramped, that is, half an hour later with a weight of fifteen pounds to the square inch, the layer was  $34\frac{1}{2}$  inches thick, giving a weight of 23 pounds to the cubic foot. In another hour, with a weight on top of 95 pounds to the square foot, the layer had been squeezed five inches thinner and weighed 27 pounds to the cubic foot. The next morning with an average pressure of about 213 pounds to the square foot, the layer weighed 31 pounds to the cubic foot. During the next two days the silo was filled up, covered with wet straw, allowed to stand four days and then covered with wet dirt. This gave an average pressure of 323 pounds to the square foot. Three days later, that is ten days after the corn was put in the silo, the bottom layer had settled 7 inches to  $18\frac{1}{2}$  inches thick, or 44 pounds to the cubic foot. Six weeks later it had settled two inches more and another inch in the next month. It then weighed 50.7 pounds to the cubic foot. When the pressure was removed by the throwing out of the upper layers, this bottom layer expanded one inch from  $15\frac{1}{2}$  to  $16\frac{1}{2}$  inches, or from 50.7 pounds to the cubic foot to 47.9 pounds.

The next to the bottom layer contained 9721 pounds of fodder corn. An hour after it was put in the silo, when it was weighted 35 pounds to the square foot, it made a layer 58 inches thick, or 20 pounds to the cubic foot. By the next day at noon, with 125 pounds of weight to the square foot, the layer had been reduced to 48 inches thick or 24 pounds to the cubic foot. At the end of eight days, with an average pressure of 244 pounds per square foot, it had shrunk a quarter more and weighed 31 pounds to the cubic foot. Ten weeks later, when the bottom layer weighed 50.7 pounds to the cubic foot, this layer weighed but 33.3 pounds. One had a pressure of 244 pounds and the other 323 pounds per square foot and the one with the lighter pressure is the heavier proportional to the pressure.

The third layer from the bottom contained 9997 pounds fodder corn. An hour after it was put in, with a pressure of 25 pounds per square foot, it was 57 inches thick or 21 pounds to the cubic foot. Eight days later, with an average pressure of 145 pounds per square foot, the layer was 39.5 inches thick, 30.3 pounds per cubic foot. Here, again, the weight per cubic foot is not proportional to the pressure. It did not change from this weight, compressing only to 31.5 pounds per cubic foot at the lowest. When the cover and upper layer were removed the top of this third layer rose two and a half inches, this being the amount that the whole mass of the three layers below expanded. This expansion seemed to be one inch for the first and third layers and half



an inch for the middle layer. As the three layers together were 88 inches thick, the expansion was but three per cent when a weight of 95 pounds per square foot was removed.

The three layers together were 88 inches thick and averaged 36 pounds per cubic foot with a pressure above 95 pounds per square foot, or an average pressure for the whole of 226 pounds per square foot. It has been estimated that it requires a pressure of about 1500 pounds per square foot or about ten pounds to the square inch to compress ensilage to its least possible bulk, when it will weigh nearly 64 pounds to the cubic foot. This is on supposition that the fodder corn is properly matured. The greener the corn the more it will weigh to the cubic foot with small pressures and the less pressure it will take to force out the last of the air.

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#### B—SEED CORN FROM DIFFERENT ALTITUDES AND LATITUDES.

A test was made extending over four years to see whether the altitude or latitude of the place at which the seed was grown would have any effect on the yield when planted in Colorado. Or, to put the problem in a little different words, to see whether Colorado grown seed was better or poorer than that grown further east. The two varieties, Pride of the North and Leaming, were selected for the test since they are the largest corn that will ripen at Fort Collins, and the seed is handled by most of the large seed dealers. Fort Collins is out of the main corn belt so that none of the yields are so high per acre as are commonly obtained in the Mississippi Valley, nor nearly so large as would be grown in the Arkansas Valley in this State. But the principle of comparison is the same, even with the smaller yields. The following tables give the weight per acre of the whole crop or what it would yield if grown for ensilage and also the weight per acre of shelled corn.

WEIGHT OF WHOLE CROP PER ACRE.

Pride of the North.

| State             | Firm                      | 1895<br>lbs. | 1897<br>lbs. | 1898<br>lbs. | 1899<br>lbs. | Aver'ge<br>lbs. |
|-------------------|---------------------------|--------------|--------------|--------------|--------------|-----------------|
| Nebraska.....     | Nebraska Seed Co.....     | 14250        | .....        | .....        | .....        | 14250           |
| Colorado.....     | Lee-Kinsey.....           | 18500        | 16000        | 6375         | 12666        | 13385           |
| ".....            | Barteldes & Co.....       | 14875        | .....        | 8000         | 14833        | 12569           |
| Pennsylvania..... | W. H. Maule.....          | 20625        | .....        | .....        | .....        | 20625           |
| Illinois.....     | Vaughn Seed Store.....    | 18875        | .....        | .....        | .....        | 18875           |
| Colorado.....     | Matthews.....             | 16750        | .....        | .....        | .....        | 16750           |
| Iowa.....         | Iowa Seed Co.....         | .....        | 17500        | 6625         | 6538         | 10221           |
| Minnesota.....    | Northrop King & Co.....   | .....        | 10666        | 3250         | 7142         | 7019            |
| Illinois.....     | J. Bauscher.....          | .....        | 14446        | 10500        | 7602         | 10839           |
| Minnesota.....    | L. L. May Co.....         | .....        | 13500        | 6500         | 12934        | 10978           |
| Pennsylvania..... | W. A. Burpee.....         | .....        | 10833        | 6000         | 8111         | 8314            |
| Ohio.....         | Storrs Harrison & Co..... | .....        | 12416        | 5875         | 9818         | 9369            |
| New York.....     | J. M. Thorburn.....       | .....        | 21750        | 10000        | 15522        | 15757           |
| Illinois.....     | H. W. Buckbee.....        | .....        | 11083        | 3125         | 7659         | 7289            |
| Michigan.....     | D. M. Ferry.....          | .....        | 3250         | 6125         | 8553         | 6009            |

WEIGHT OF SHELLED CORN PER ACRE.

Pride of the North.

| State             | Firm                      | 1897<br>lbs. | 1898<br>lbs. | 1899<br>lbs. | Aver'ge<br>lbs. |
|-------------------|---------------------------|--------------|--------------|--------------|-----------------|
| Iowa.....         | Iowa Seed Co.....         | 2000         | 900          | 1730         | 1543            |
| Minnesota.....    | Northrop King & Co.....   | 1833         | 652          | 2261         | 1582            |
| Colorado.....     | Lee-Kinsey.....           | 1000         | 795          | 2666         | 1487            |
| Illinois.....     | J. Bauscher.....          | 1333         | 1656         | 2142         | 1710            |
| Minnesota.....    | L. L. May Co.....         | 1416         | 840          | 2375         | 1543            |
| Pennsylvania..... | W. A. Burpee.....         | 1250         | 997          | 2000         | 1415            |
| Ohio.....         | Storrs Harrison & Co..... | 750          | 787          | 2000         | 1179            |
| New York.....     | J. M. Thorburn.....       | 2166         | 785          | 2537         | 1812            |
| Illinois.....     | H. W. Buckbee.....        | 1583         | 850          | 2123         | 1520            |
| Michigan.....     | D. M. Ferry.....          | 166          | 1087         | 2596         | 1283            |
| Colorado.....     | Barteldes & Co.....       | .....        | 840          | 2166         | 1503            |



## WEIGHT OF WHOLE CROP PER ACRE.

Leaming.

| State              | Firm                      | 1895<br>lbs. | 1897<br>lbs. | 1898<br>lbs. | 1899<br>lbs. | Aver'ge<br>lbs. |
|--------------------|---------------------------|--------------|--------------|--------------|--------------|-----------------|
| Nebraska.....      | Nebraska Seed Co .....    | 19250        | .....        | .....        | .....        | 19250           |
| Pennsylvania.....  | D. Landreth .....         | 18500        | 18416        | .....        | 13500        | 16805           |
| " .....            | W. H. Maule .....         | 20875        | 14833        | 7500         | 17900        | 15277           |
| Illinois.....      | Vaughn Seed Store.....    | 17000        | .....        | .....        | .....        | 17000           |
| Iowa .....         | Iowa Seed Co.....         | .....        | 20250        | 11000        | 15319        | 15523           |
| Minnesota.....     | Northrop King & Co.....   | 19625        | 21083        | 6750         | 10769        | 14566           |
| California.....    | Cox Seed Co .....         | .....        | 20833        | 6000         | 14318        | 13717           |
| Colorado.....      | Barteldes & Co.....       | 15125        | 27750        | 10000        | 6018         | 14723           |
| Massachusetts..... | R. & J. Farquhar.....     | .....        | 23250        | .....        | 13205        | 18223           |
| Minnesota .....    | L. L. May Co .....        | .....        | 24833        | 8250         | 15925        | 16336           |
| Wisconsin.....     | J. A. Salzer .....        | .....        | 24333        | 9375         | 13921        | 15876           |
| Pennsylvania ..... | W. A. Burpee.....         | .....        | 20166        | 2375         | 13571        | 12204           |
| Ohio.....          | Storrs Harrison & Co..... | .....        | 20166        | 8000         | 15106        | 14424           |
| New York.....      | J. M. Thorburn .....      | .....        | 17333        | 4875         | 12708        | 11638           |
| Illinois.....      | H. W. Buckbee.....        | .....        | 22000        | 6875         | 14411        | 14428           |
| Massachusetts..... | J. J. H. Gregory .....    | .....        | 25416        | 10250        | 13921        | 16529           |
| Pennsylvania.....  | Johnson Stokes & Co.....  | .....        | 14750        | 4000         | 14857        | 11262           |

## WEIGHT OF SHELLED CORN PER ACRE.

Leaming.

| State              | Firm                      | 1897<br>lbs. | 1898<br>lbs. | 1899<br>lbs. | Aver'ge<br>lbs. |
|--------------------|---------------------------|--------------|--------------|--------------|-----------------|
| Iowa .....         | Iowa Seed Co.....         | 1750         | 1182         | 2659         | 1864            |
| Minnesota.....     | Northrop King & Co.....   | 2250         | 945          | 2692         | 1962            |
| California.....    | Cox Seed Co .....         | 2000         | 575          | 2613         | 1729            |
| Colorado.....      | Barteldes & Co.....       | 1666         | 340          | 1481         | 1296            |
| Massachusetts..... | R. & J. Farquhar .....    | 2083         | .....        | 1923         | 2003            |
| Pennsylvania ..... | D. Landreth .....         | 1750         | .....        | 1800         | 1775            |
| Minnesota.....     | L. L. May Co.....         | 2000         | 822          | 2692         | 1838            |
| Wisconsin.....     | J. A. Salzer.....         | 2083         | 537          | 1764         | 1461            |
| Pennsylvania ..... | W. A. Burpee.....         | 1750         | .....        | 1982         | 1866            |
| " .....            | W. H. Maule .....         | 666          | 472          | 3000         | 1379            |
| Ohio .....         | Storrs Harrison & Co..... | 1166         | 591          | 2021         | 1259            |
| New York .....     | J. M. Thorburn .....      | 2000         | 505          | 1458         | 1321            |
| Illinois.....      | H. W. Buckbee.....        | 2083         | 577          | 2745         | 1801            |
| Massachusetts..... | J. J. H. Gregory.....     | 2750         | 618          | 2058         | 1809            |
| Pennsylvania ..... | Johnson Stokes & Co.....  | 1416         | 410          | 2142         | 1323            |

The results are not at all uniform, but it seems possible to draw the conclusions that the seed grown in Colorado produces just about the average of that grown in all the other states for Pride of the North, and less than the average for the Leaming. The northern grown seed shows poorly for Pride of the North and among the best for the Leaming. The eastern grown seed Massachusetts, Pennsylvania and New York on the whole gives better returns than that grown west of the Mississippi river.

#### C---VARIETY TESTS OF CORN.

For the past six years there have a large number of the principal varieties of corn been grown on the college farm. It is believed that the results of so long a test will prove valuable as giving a clear indication of the general kind and size of corn that will do the best under the given conditions of altitude and latitude. All grades were tested, from the Will's Gehu that ripens long before frost and bears its ears less than a foot from the ground, to the Giant Mexican June that sends out its silk as high as a man can reach and is barely tasseling at the usual harvest time.

In all cases the corn was planted in hills three feet apart each way. In 1895 it was not irrigated and the crop was small. The other years the corn was irrigated twice. The land on which this corn was grown was a different field each year and was for the most part on ground that had been heavily manured. In all cases it was land so rich and in such condition that it would have raised a large crop of grain. In other words the small crops are due to the climate rather than the soil, and show that Fort Collins is outside of the corn belt. Still, corn will grow here so well that if it was not for the ease and cheapness with which alfalfa can be grown, corn would be the cheapest fodder for dairy stock.

#### VARIETY TESTS OF CORN 1894.

| Variety.             | Total Crop<br>per acre. | Green Ears<br>per acre. | Green Stover<br>per acre. | Shelled Corn<br>per acre. |
|----------------------|-------------------------|-------------------------|---------------------------|---------------------------|
| Flint Corn—          |                         |                         |                           |                           |
| Golden Dew Drop..    | 16,800                  | 4,820                   | 11,980                    | 1,926                     |
| Will's Gehu .....    | 14,200                  | 4,900                   | 9,300                     | 2,117                     |
| King Philip.....     | 19,200                  | 3,600                   | 15,200                    | 1,028                     |
| Sanford .....        | 23,400                  | 5,300                   | 18,100                    | 1,809                     |
| Longfellow .....     | 19,600                  | 3,850                   | 15,750                    | 1,327                     |
| Minn. King.....      | 14,200                  | 2,900                   | 11,300                    | 1,176                     |
| Dent Corn—           |                         |                         |                           |                           |
| Queen of the Field.. | 22,800                  | 6,300                   | 16,500                    | 1,686                     |
| Huron.....           | 18,400                  | 5,423                   | 12,977                    | 2,408                     |
| White Pearl .....    | 21,400                  | 6,869                   | 14,531                    | 2,408                     |



| Variety.              | Total Crop<br>per acre. | Green Ears<br>per acre. | Green Stover<br>per acre. | Shelled Corn<br>per acre. |
|-----------------------|-------------------------|-------------------------|---------------------------|---------------------------|
| Wis. Yellow Dent...   | 21,600                  | 5,900                   | 15,700                    | 2,167                     |
| Pride of the North..  | 24,800                  | 5,800                   | 19,000                    | 1,809                     |
| Cali. Yellow.....     | 22,400                  | 6,250                   | 16,150                    | 1,926                     |
| Mastodon.....         | 25,000                  |                         |                           |                           |
| Chester County Mam.   | 21,200                  |                         |                           |                           |
| Red Cob.....          | 23,200                  |                         |                           |                           |
| Champ. Co. Prolific.. | 23,000                  |                         |                           |                           |
| Leaming.....          | 30,800                  |                         |                           |                           |
| Giant Fodder.....     | 35,000                  |                         |                           |                           |
| Va. Mammoth.....      | 20,800                  |                         |                           |                           |

## VARIETY TESTS OF CORN 1895.

|                       |        |       |        |
|-----------------------|--------|-------|--------|
| Flint Corn—           |        |       |        |
| Golden Dew Drop...    | 12,100 | 2,600 | 9,500  |
| Will's Gehu .....     | 7,875  | 3,750 | 4,125  |
| King Philip.....      | 13,000 | 3,100 | 9,900  |
| Sanford .....         | 14,750 | 4,375 | 10,375 |
| Longfellow .....      | 14,200 | 2,000 | 12,200 |
| Minn. King .....      | 13,000 | 3,900 | 9,100  |
| White Australian...   | 18,600 | 6,500 | 12,100 |
| Angel of Midnight..   | 12,600 | 2,000 | 10,600 |
| Yellow Australian..   | 10,700 | 4,700 | 6,000  |
| Colorado White.....   | 25,100 | 4,400 | 20,700 |
| Brazilian Flour....   | 18,000 | ....  | 18,000 |
| Dent Corn—            |        |       |        |
| King of the Earliest. | 20,400 | 3,900 | 16,500 |
| Queen of the Field..  | 18,500 | 5,500 | 13,000 |
| Huron.....            | 12,100 | 3,800 | 8,300  |
| White Pearl .....     | 14,700 | 1,900 | 12,800 |
| Pride of the North..  | 17,500 | 4,000 | 13,500 |
| Gold Mine.....        | 18,000 | 4,500 | 13,500 |
| White Cap Dent....    | 17,000 | 2,300 | 14,700 |
| Grafflin.....         | 15,700 | 4,000 | 11,700 |
| Riley's Favorite..... | 19,000 | 2,700 | 16,300 |
| Mastodon.....         | 15,250 | 1,751 | 13,500 |
| Red Cob.....          | 20,000 | ....  | 20,000 |
| Leaming.....          | 18,400 | 3,750 | 14,650 |
| Giant White Dent...   | 18,400 | 2,200 | 16,200 |
| Conqueror.....        | 7,000  | 900   | 6,100  |
| Mam. Cuban.....       | 20,400 | 4,400 | 16,000 |
| Mam. Red .....        | 20,500 | 4,500 | 16,000 |
| Giant Mex. June....   | 13,600 | ....  | 13,600 |
| Swadley .....         | 11,100 | 4,900 | 6,200  |
| Golden Row .....      | 20,700 | 2,700 | 18,000 |
| Golden Beauty.....    | 22,200 | 3,700 | 18,500 |
| Nebr. White Prize..   | 17,400 | 3,200 | 14,200 |
| Early California...   | 21,000 | 4,000 | 17,000 |
| Golden Seal .....     | 23,700 | 5,200 | 18,500 |
| Hathaway's Yel. Dent  | 18,700 | 8,500 | 10,200 |
| Evergreen Sweet....   | 15,600 | 3,400 | 12,200 |

## VARIETY TESTS OF CORN 1896.

|                      |        |       |        |
|----------------------|--------|-------|--------|
| Flint Corn—          |        |       |        |
| Golden Dew Drop..    | 24,500 | 3,750 | 21,750 |
| Will's Gehu.....     | 9,300  | 4,100 | 5,200  |
| King Philip.....     | 19,250 | 3,830 | 15,420 |
| Sanford .....        | 24,100 | 4,500 | 19,600 |
| Longfellow .....     | 25,800 | 2,580 | 23,220 |
| White Australian...  | 19,500 | 6,100 | 13,400 |
| Angel of Midnight..  | 16,100 | 1,600 | 14,500 |
| Yellow Australian... | 6,800  | 2,300 | 4,500  |
| Colorado White.....  | 27,600 | 4,700 | 22,900 |

| Variety.              | Total Crop<br>per acre. | Green Ears<br>per acre. | Green Stover<br>per acre. | Shelled Corn<br>per acre. |
|-----------------------|-------------------------|-------------------------|---------------------------|---------------------------|
| Brazilian Flour.....  | 44,500                  | ....                    | 44,500                    | ....                      |
| Dent Corn—            |                         |                         |                           |                           |
| Queen of the Field..  | 22,200                  | 6,250                   | 15,950                    | 2,750                     |
| White Pearl.....      | 20,500                  | 2,700                   | 17,800                    | 500                       |
| Pride of the North..  | 19,700                  | 4,600                   | 15,100                    | 2,250                     |
| Dakota Dent.....      | 16,000                  | 4,000                   | 12,000                    | 1,900                     |
| Gold Mine.....        | 17,500                  | 4,800                   | 12,700                    | ....                      |
| White Cap Dent....    | 24,700                  | 4,900                   | 19,800                    | ....                      |
| Grafflin.....         | 17,800                  | 4,000                   | 13,800                    | 1,600                     |
| Riley's Favorite..... | 20,300                  | 2,700                   | 17,600                    | ....                      |
| Mastodon.....         | 18,200                  | 3,250                   | 14,950                    | 1,000                     |
| Red Cob.....          | 33,200                  | 3,900                   | 29,300                    | ....                      |
| Leaming.....          | 18,700                  | 4,400                   | 14,300                    | 2,400                     |
| Giant White Dent..    | 16,600                  | 1,600                   | 15,000                    | 250                       |
| Conquerer.....        | 14,400                  | 1,600                   | 12,800                    | ....                      |
| Mam. Cuban.....       | 21,100                  | 5,200                   | 15,900                    | 1,900                     |
| Mam. Red.....         | 19,000                  | 3,200                   | 15,800                    | ....                      |
| Giant Mex. June....   | 84,000                  | ....                    | 84,000                    | ....                      |
| Swadley.....          | 10,800                  | 3,800                   | 7,000                     | 2,000                     |
| Golden Row.....       | 31,000                  | 5,700                   | 25,300                    | 1,900                     |
| Golden Beauty.....    | 27,200                  | 5,300                   | 21,900                    | ....                      |
| Neb. White Prize...   | 22,700                  | 3,100                   | 19,600                    | 750                       |
| Early California .... | 24,100                  | 3,700                   | 20,400                    | ....                      |
| Golden Seal.....      | 13,200                  | 3,400                   | 9,800                     | 1,300                     |
| Hathaway's Yellow     |                         |                         |                           |                           |
| Dent.....             | 18,100                  | 6,100                   | 12,000                    | ....                      |
| Evergreen Sweet....   | 20,700                  | 1,700                   | 19,000                    | 500                       |

## VARIETY TESTS OF CORN 1897.

|                       |        |       |        |       |
|-----------------------|--------|-------|--------|-------|
| Flint Corn—           |        |       |        |       |
| Sanford.....          | 13,750 | 2,667 | 11,083 | 1,250 |
| Longfellow.....       | 16,861 | 2,917 | 13,944 | 1,139 |
| White Australian...   | 15,583 | 4,333 | 11,250 | 2,250 |
| Angel of Midnight..   | 16,000 | 4,083 | 11,917 | 1,750 |
| Squaw Corn.....       | 7,167  | 3,000 | 4,167  | 2,083 |
| Compton's Early....   | 17,250 | 2,917 | 14,333 | 1,417 |
| Earliest Ripe.....    | 4,416  | 2,033 | 2,333  | 1,250 |
| Early Canada.....     | 12,666 | 2,833 | 9,833  | 1,333 |
| Minn. White Flint..   | 17,666 | 4,583 | 13,033 | 2,250 |
| Red-blazed.....       | 9,750  | 1,500 | 8,250  | 750   |
| Pride of Canada....   | 13,000 | 2,250 | 10,750 | 1,167 |
| Brazilian Flour.....  | 21,500 | ....  | 21,500 | ....  |
| White Flint.....      | 14,583 | 3,250 | 11,343 | 1,167 |
| Dent Corn—            |        |       |        |       |
| Pride of the North..  | 14,242 | 3,371 | 10,871 | 1,568 |
| Dakota Dent.....      | 8,666  | 3,083 | 5,583  | 1,416 |
| Huron.....            | 17,333 | 3,583 | 13,750 | 1,833 |
| Gold Mine.....        | 17,333 | 3,250 | 14,083 | 1,417 |
| Grafflin.....         | 12,333 | 2,333 | 1,000  | 2,000 |
| King of the Earliest, | 20,083 | 3,667 | 16,416 | 1,667 |
| Iowa Silver Mine....  | 18,667 | 3,167 | 15,500 | 1,167 |
| Red Cob.....          | 40,333 | 7,583 | 32,750 | 2,333 |
| Leaming.....          | 21,028 | 4,589 | 16,439 | 1,761 |
| Cuban Giant.....      | 17,333 | 1,917 | 15,417 | 500   |
| Giant Mex. June....   | 44,417 | ....  | 44,417 | ....  |
| Swadley.....          | 12,500 | 3,250 | 8,250  | 1,583 |
| Golden Beauty.....    | 20,875 | 3,792 | 17,083 | 1,209 |
| Evergreen Sweet....   | 20,667 | 3,000 | 17,667 | 750   |
| Blount's Mammoth.     | 25,167 | 4,500 | 20,667 | 1,250 |



## VARIETY TESTS OF CORN, 1898.

| Variety.              | Total Crop<br>per acre. | Green Ears<br>per acre. | Green Stover<br>per acre. | Shelled Corn<br>per acre. |
|-----------------------|-------------------------|-------------------------|---------------------------|---------------------------|
| Flint Corn—           |                         |                         |                           |                           |
| Sanford .....         | 7,125                   | 1,125                   | 6,000                     |                           |
| Longfellow .....      | 6,708                   | 1,333                   | 5,375                     |                           |
| Angel of Midnight ..  | 8,500                   | 1,500                   | 7,000                     |                           |
| Squaw Corn.....       | 5,375                   | 3,250                   | 2,125                     |                           |
| Compton's Early ...   | 7,500                   | 1,250                   | 6,250                     |                           |
| Early Red Blazed...   | 6,750                   | 1,500                   | 5,250                     |                           |
| Pride of Canada....   | 10,625                  | 2,000                   | 8,625                     |                           |
| Dent Corn—            |                         |                         |                           |                           |
| Pride of the North..  | 6,438                   | 1,750                   | 4,688                     | 930                       |
| Dakota Dent.....      | 3,125                   | 1,500                   | 1,625                     |                           |
| Early Huron.....      | 5,625                   | 1,750                   | 3,875                     |                           |
| Gold Mine.....        | 8,625                   | 2,375                   | 6,250                     |                           |
| Grafflin.....         | 5,875                   | 2,250                   | 3,625                     |                           |
| King of the Earliest. | 8,125                   | 1,375                   | 6,750                     |                           |
| Silver Mine.....      | 11,875                  | 2,250                   | 9,625                     |                           |
| Red Cob.....          | 12,125                  | 375                     | 11,755                    |                           |
| Leaming .....         | 7,365                   | 1,448                   | 5,917                     | 642                       |
| Cuban Giant.....      | 8,375                   | 750                     | 7,625                     |                           |
| Giant Mexican.....    | 9,750                   | ....                    | ....                      |                           |
| Evergreen .....       | 4,500                   | 500                     | 4,000                     |                           |
| Blount's Mammoth..    | 5,875                   | ....                    | ....                      |                           |

## VARIETY TESTS OF CORN, AVERAGE OF 1894-1898.

|                             |        |        |        |       |
|-----------------------------|--------|--------|--------|-------|
| Flint Corn—                 |        |        |        |       |
| Golden Dew Drop..           | 17,800 | 3,723  | 14,808 | 1,798 |
| Will's Gehu.....            | 10,458 | 4,250  | 6,208  | 2,857 |
| King Philip.....            | 17,150 | 3,510  | 13,640 | 1,464 |
| Sanford .....               | 16,625 | 3,593  | 13,032 | 1,492 |
| Longfellow .....            | 16,634 | 2,536  | 14,098 | 1,185 |
| Minn. King.....             | 13,600 | 3,400  | 10,200 | 1,176 |
| White Australian... 17,894  | 5,644  | 12,250 | 2,625  |       |
| Angel of Midnight..         | 13,400 | 2,296  | 11,104 | 1,025 |
| Yellow Australian... 8,750  | 3,500  | 5,250  | 1,100  |       |
| Colorado White.....         | 26,350 | 4,550  | 21,800 | 1,400 |
| Brazilian Flour.....        | 28,000 | ....   | 28,000 | ....  |
| Squaw Corn.....             | 6,271  | 3,125  | 3,146  | 2,083 |
| Compton's Early....         | 12,375 | 2,084  | 10,291 | 1,417 |
| Earliest Ripe.....          | 4,416  | 2,083  | 2,333  | 1,250 |
| Early Canada.....           | 12,666 | 2,833  | 9,833  | 1,333 |
| Minn. White Flint... 17,666 | 4,583  | 13,083 | 2,250  |       |
| Red-blazed .....            | 8,250  | 1,500  | 6,750  | 750   |
| Pride of Canada....         | 11,813 | 2,125  | 9,688  | 1,167 |
| White Flint.....            | 14,583 | 3,250  | 11,333 | 1,167 |
| Dent Corn—                  |        |        |        |       |
| Queen of the Field..        | 21,167 | 6,017  | 15,150 | 2,218 |
| Huron.....                  | 14,115 | 3,639  | 10,476 | 2,121 |
| White Pearl.....            | 18,867 | 3,823  | 15,044 | 1,954 |
| Wis. Yellow Dent... 21,600  | 5,900  | 15,700 | 2,167  |       |
| Pride of the North..        | 16,536 | 3,904  | 12,632 | 1,639 |
| Cal. Yellow.....            | 22,400 | 6,250  | 16,150 | 1,926 |
| Mastodon.....               | 19,483 | 2,500  | 16,983 | 1,000 |
| Chester Co. Mam... 21,200   | ....   | ....   | ....   |       |
| Red Cob.....                | 25,772 | 3,953  | 21,819 | 2,333 |
| Champ Co. Prolific..        | 23,000 | ....   | ....   | ....  |
| Leaming .....               | 19,259 | 3,547  | 15,712 | 1,601 |
| Giant Fodder.....           | 35,000 | ....   | ....   | ....  |
| Va. Mammoth.....            | 20,800 | ....   | ....   | ....  |
| King of the Earliest.       | 16,203 | 2,981  | 14,222 | 1,667 |
| Gold Mine.....              | 15,365 | 3,731  | 11,634 | 1,417 |
| White Cap Dent....          | 20,850 | 3,600  | 17,250 | ....  |

| Variety.                       | Total Crop<br>per acre. | Green Ears<br>per acre. | Green Stover<br>per acre. | Shelled Corn<br>per acre. |
|--------------------------------|-------------------------|-------------------------|---------------------------|---------------------------|
| Grafflin.....                  | 12,927                  | 3,146                   | 9,781                     | 1,800                     |
| Riley's Favorite.....          | 19,650                  | 2,700                   | 16,850                    | .....                     |
| Giant White Dent..             | 17,500                  | 1,900                   | 15,600                    | 250                       |
| Conqueror.....                 | 10,700                  | 1,250                   | 9,450                     | .....                     |
| Mam. Cuban.....                | 20,750                  | 4,800                   | 15,950                    | 1,900                     |
| Mammoth Red.....               | 19,750                  | 3,850                   | 15,900                    | .....                     |
| Giant Mex. June....            | 37,942                  | .....                   | 37,942                    | .....                     |
| Swadley.....                   | 11,467                  | 3,983                   | 7,484                     | 1,792                     |
| Golden Row.....                | 25,850                  | 4,200                   | 21,650                    | 1,900                     |
| Golden Beauty.....             | 23,425                  | 4,264                   | 19,161                    | 1,209                     |
| Neb. White Prize...            | 20,050                  | 3,150                   | 16,900                    | 750                       |
| Early California....           | 22,550                  | 3,850                   | 18,700                    | .....                     |
| Golden Seal.....               | 18,450                  | 4,300                   | 14,150                    | 1,300                     |
| Hathaway's Yellow<br>Dent..... | 18,400                  | 7,300                   | 11,100                    | .....                     |
| Evergreen Sweet....            | 15,367                  | 2,150                   | 13,217                    | 625                       |
| Dakota Dent.....               | 9,264                   | 2,861                   | 6,403                     | 1,658                     |
| Iowa Silver Mine...            | 15,271                  | 2,709                   | 12,562                    | 1,167                     |
| Cuban Giant.....               | 12,854                  | 1,334                   | 11,520                    | 500                       |
| Blount's Mammoth..             | 15,021                  | 4,500                   | 10,521                    | 1,250                     |

D—NUMBER OF STALKS IN A HILL.

The effect on the yield of the corn, of a different number of stalks in a hill, was noted two different years. The first year the crop was rather larger than an average crop in this part of Colorado. The number of stalks in each hill was counted and the weight of each hill recorded. Omitting the outside rows leaves 320 hills, which were divided as follows:

| No. of Stalks Per Hill       | No. of Hills containing this No. of Stalks | Per Cent of Total No. of Hills | Total Weight | Average Weight Per Hill | Average Weight Per Stalk |
|------------------------------|--------------------------------------------|--------------------------------|--------------|-------------------------|--------------------------|
| 0                            | 76                                         | 24                             | 0            | 0                       | 0                        |
| 1                            | 22                                         | 7                              | 60           | 2.7                     | 2.7                      |
| 2                            | 30                                         | 9                              | 133          | 4.4                     | 2.2                      |
| 3                            | 52                                         | 16                             | 284          | 5.5                     | 1.8                      |
| 4                            | 56                                         | 17                             | 397          | 7.1                     | 1.8                      |
| 5                            | 47                                         | 15                             | 375          | 8.0                     | 1.6                      |
| 6                            | 29                                         | 9                              | 260          | 9.0                     | 1.5                      |
| 7                            | 6                                          | 2                              | 53           | 9.0                     | 1.3                      |
| 8                            | 1                                          | 0                              | 11           | 11.0                    | 1.4                      |
| Av. and Total..3             | 320                                        | 100                            | 1513         | 4.7                     | 1.6                      |
| Omitting missing hills.....4 | 244                                        |                                | 1513         | 6.2                     | 1.6                      |



It will be noted that as the number of stalks in a hill increases, the size of each stalk diminishes, but the increase in number much more than overbalances the decrease in size and the weight of the hill is greater the larger the number of stalks. A hill containing six stalks weighs much more than a hill of one stalk, but instead of weighing six times as much, it weighs a little more than three times as much.

The same principle is seen the second year when a larger number of hills was weighed from a field having rather less than an average crop in size.

| No. of Stalks Per Hill       | No. of Hills containing this No. of Stalks | Per Cent of Total No. of Hills | Total Weight | Average Weight Per Hill | Average Weight Per Stalk |
|------------------------------|--------------------------------------------|--------------------------------|--------------|-------------------------|--------------------------|
| 0                            | 167                                        | 14                             | 0            | 0                       | 0                        |
| 1                            | 58                                         | 7                              | 97           | 1.7                     | 1.70                     |
| 2                            | 130                                        | 16                             | 339          | 3                       | 1.50                     |
| 3                            | 271                                        | 35                             | 1053         | 3.9                     | 1.30                     |
| 4                            | 162                                        | 21                             | 687          | 4.2                     | 1.05                     |
| 5                            | 46                                         | 6                              | 243          | 5.3                     | 1.06                     |
| 6                            | 10                                         | 1                              | 62           | 6.3                     | 1.05                     |
| Average and Total,           | 784                                        | 100                            | 2533         | 3.5                     | 1.22                     |
| Omitting missing hills ..... | 677                                        | 86                             | 2533         | 4.1                     | 1.22                     |

There is no indication in the figures of either year as given in this form that the increase could not go on indefinitely. The larger the number of stalks the larger the weight of the hill seems to be the rule. But there really is a limit. If each hill was by itself with plenty of space on all sides, the above rule would be true. When, however, the hills are only three feet apart, as was the case in these fields, there is room for only a certain number of stalks to grow and develop on a given area. The addition of one more plant to a hill not only decreases the size of the other plants in that hill, but it also decreases the size of each of the four hills surrounding it. If these several losses amount to more than the weight of the extra plant, then its presence in the field is a positive loss. For each field there is such a point and when that point is reached is the number of stalks per hill that gives the largest yield of crop per acre. To learn what this number is, the number of stalks in the four hills next to each hill was then counted and the weight of the hill recorded. Combining these data and interpolating to get even numbers, gives the results below;

| No. of stalks in a hill. | Average No. of stalks in the 4 hills about it. | Weight of the hill lbs. | Weight per acre tons. |
|--------------------------|------------------------------------------------|-------------------------|-----------------------|
| 1                        | 1                                              | 3.5                     | 8.7                   |
|                          | 3                                              | 2.6                     | 6.2                   |
| 2                        | 2                                              | 4.6                     | 11.5                  |
|                          | 3                                              | 4.5                     | 11.2                  |
| 3                        | 3                                              | 5.4                     | 13.5                  |
|                          | 4                                              | 4.6                     | 10.5                  |
| 4                        | 3                                              | 6.8                     | 17.0                  |
|                          | 4                                              | 6.2                     | 15.5                  |
|                          | 5                                              | 5.9                     | 14.7                  |
| 5                        | 3                                              | 8.0                     | 20.0                  |
|                          | 4                                              | 8.0                     | 20.0                  |
|                          | 5                                              | 7.6                     | 19.0                  |
| 6                        | 5                                              | 7.3                     | 18.2                  |
|                          | 6                                              | 7.0                     | 17.5                  |

From the last table we can estimate the yield per acre from the different number of stalks in a hill:

6 stalks per hill give a crop of 17.5 tons per acre

|   |   |   |   |   |      |   |   |
|---|---|---|---|---|------|---|---|
| 5 | " | " | " | " | 19.0 | " | " |
| 4 | " | " | " | " | 15.5 | " | " |
| 3 | " | " | " | " | 13.5 | " | " |
| 2 | " | " | " | " | 11.5 | " | " |
| 1 | " | " | " | " | 8.7  | " | " |

Half 4 stalks and half 5 stalks 17.0 " "

If the hills are equally divided among the different numbers from one to six, the resulting crop would be about 14.0 tons per acre.

These figures show that in this field the largest crop would be obtained from five stalks in each hill. If a hill contained six stalks, with five stalks in each hill surrounding it, the extra stalk caused a net loss of about a third of a pound per hill, showing but slight loss, while if it contained four stalks, or one less than the best number, the net loss was 1.7 pounds per hill.

The next year shows some unexpected figures. It had been supposed that with a lighter crop of smaller stalks, the field would support a greater number of stalks, but the figures do not seem to warrant this conclusion.

| No. of stalks in a hill. | Average No. of stalks in the 4 hills around it. | Weight of the hill lbs. | Weight per acre tons. |
|--------------------------|-------------------------------------------------|-------------------------|-----------------------|
| 1                        | 1                                               | 2.12                    | 5.3                   |
|                          | 3                                               | 1.57                    | 3.9                   |
| 2                        | 2                                               | 3.31                    | 8.3                   |
|                          | 3                                               | 2.80                    | 7.0                   |
| 3                        | 3                                               | 3.94                    | 9.8                   |
|                          | 4                                               | 3.45                    | 8.6                   |
| 4                        | 3                                               | 4.66                    | 11.6                  |
|                          | 4                                               | 4.57                    | 11.4                  |
|                          | 5                                               | 4.21                    | 10.5                  |
| 5                        | 3                                               | 5.01                    | 12.5                  |
|                          | 4                                               | 4.52                    | 11.3                  |
|                          | 5                                               | 3.87                    | 9.7                   |



It is evident here that the largest crop is one that has four stalks in each hill, since the weights with the different numbers of stalks give:

|                                  |                   |
|----------------------------------|-------------------|
| 5 stalks per hill give a crop of | 9.7 tons per acre |
| 4 " " " "                        | 11.4 " "          |
| 3 " " " "                        | 9.8 " "           |
| 2 " " " "                        | 8.3 " "           |
| 1 " " " "                        | 5.3 " "           |

Since this field gives a smaller crop per acre from smaller stalks, and yet gives a larger return from four stalks in a hill than from five stalks, it cannot be said that it is always better to have less stalks in a hill, the larger the variety of corn.

Since these two crops represent a good share of the crops of northern Colorado, it can be said that where corn is raised for fodder four or five stalks in a hill, if the hills are three feet apart each way, gives the largest crop per acre.

#### E—MISSING HILLS IN A CORN FIELD.

One of the largest sources of loss in the cornfield is hills without any stalks. In the field of corn grown the first year, it was thought that there were not enough hills missing to pay for replanting, but when harvest came, the count showed 24 per cent missing or a loss in this field of about two and half tons of fodder corn, or much more than enough to have paid for the replanting.

In figuring the loss from a missing hill, two items have to be taken into account, the loss from the hill itself and the gain to the hills around it.

The first is easily told by taking the average weight of the hills which are surrounded by four full hills. The second is not so easy to ascertain. One way of estimating is to get the average weight of those hills that are next to a missing hill and compare this weight with the weight where the hills are full.

In the field the first year there were 114 hills which had a missing hill on one side of them, with an average weight 6.8 pounds. The 122 hills that were surrounded by complete hills average 6.0 pounds. This indicates an average gain of 0.8 pounds to each of the four hills surrounding a missing hill or a total gain of 3.2 pounds. But since the average weight of the hill in this field was 6.0 pounds, each hill that was missing meant a loss of 6.00 pounds and a gain of 3.2

pounds or a net loss of 2.8 pounds which is equal to 47 per cent.

The same thing was tried in another field of much heavier corn. The 165 hills surrounded by four full hills averaged 10.11 pounds each or fully twenty-five tons of fodder corn per acre. The 248 hills that were next to a missing hill averaged 10.77 pounds; a gain of 0.66 pounds for each of the four surrounding hills, making a gain of 2.64 pounds. The loss for each missing hill is 10.11 pounds and the gain 2.64 pounds, at a net loss of 7.47 pounds or 74 per cent.

Another field of rather light corn gave somewhat different results. The 216 hills near a missing hill weighed 4.27 pounds and the 392 hills fully surrounded weighed 3.52 pounds each. Here is a gain of four times 0.75 pounds or 3.00 pounds as compared with a loss of 3.52 pounds or a net loss of but 0.52 pounds equal to 15 per cent.

The three fields show most widely different results and it is evident that these differences are due to the different vigor in the growth of the crop. When a crop is of such a large rank growing variety as in the second case, and there are stalks enough in the hill to produce the maximum growth, the ground is so full of roots, that even the loss of a hill does not open up enough extra ground to add much to the weight of the surrounding hills compared with the large growth there already. While in a field with a small crop the result is relatively larger. In absolute weight of effect, a missing hill has closely the same result in all three fields. In the field with the light crop it makes a gain of 0.75 pounds for each of the four hills surrounding it; in the field of medium growth the gain is 0.80 pounds per hill and in the field with the very heavy growth 0.66 pounds per hill. The average of these is 0.74 pounds for each hill or about 3.00 pounds for the four surrounding hills. It can be said then that in general a missing hills makes a gain of about three pounds of cornfodder in the weight of the surrounding hills and a loss of the weight of an average hill of the field.



### III. POTATOES.

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#### A—ALFALFA SOD COMPARED WITH OLD LAND.

A test was made of potatoes on alfalfa sod as compared with good land that had been manured two years before and raised one crop of grain and one of corn. There were nine plots of each and though the plots are quite variable, in each case the alfalfa sod gives a larger yield than the old ground. In the plots which are the nearest alike, the yield from alfalfa sod is not quite twice that from the old ground, while in two other plots it is five times as much. The average is about three to one, being 3601 pounds of merchantable potatoes from the alfalfa sod and but 1277 pounds from the old ground.

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#### B—EXPERIMENTS WITH FERTILIZERS,

Experiments in fertilizing the ground for potatoes were made with a complete fertilizer and with kainit, sulphate of potash and muriate of potash. The complete fertilizer was bought in Denver at forty dollars per ton; the potash salts came from the Potash Trust of New York City. The fertilizer was applied at the rate of four hundred pounds per acre.

| Plot. | Fertilizer.         | Yield of potatoes. |
|-------|---------------------|--------------------|
| 1     | Nothing             | 431                |
| 2     | Sulphate of potash  | 430                |
| 3     | Muriate of potash   | 488                |
| 4     | Complete fertilizer | 576                |
| 5     | Kainit              | 665                |
| 6     | Nothing             | 689                |
| 7     | Sulphate of potash  | 628                |
| 8     | Muriate of potash   | 610                |
| 9     | Complete fertilizer | 409                |
| 10    | Kainit              | 383                |
| 11    | Nothing             | 273                |

Combining the plots gives the following averages :

|                                  |              |
|----------------------------------|--------------|
| Sulphate of potash.....          | 1058 pounds  |
| Muriate of potash.....           | 1098 "       |
| Complete fertilizer.....         | 985 "        |
| Kainit.....                      | 1048 "       |
| Nothing.....                     | 896 "        |
| Average of fertilized plots..... | 1047 "       |
| Average of unfertilized plots... | 896 "        |
| Gain from fertilization.....     | 14 per cent. |

Under ordinary prices this gain of fourteen per cent would just about pay the cost of the fertilizer, but it is evident that part of the difference in crop is due to differences in the character of the ground, so that it would be hardly safe to say that the whole of the gain of fourteen per cent was due to the fertilizer.

## IV. SUGAR BEETS.

### A—SUBSOILING FOR SUGAR BEETS.

A test was made of the effect of subsoiling the land for sugar beets as compared with simple plowing. The subsoiling was done with a Secretary plow to the depth of fourteen inches, the rest was plowed eight inches deep with a common stirring plow. The field was divided into six equal strips, alternately plowed by the two methods. The field was subsoiled in May and planted the same day. The results are given in the following table:

| Plot. | Treatment. | Crop Per Plot. |
|-------|------------|----------------|
| 1     | Plowed     | 2960           |
| 2     | Subsoiled  | 6880           |
| 3     | Plowed     | 5860           |
| 4     | Subsoiled  | 4554           |
| 5     | Plowed     | 4040           |
| 6     | Subsoiled  | 4400           |

The average of the three plots merely plowed is a crop of 4287 pounds of sugar beets, while the three plots subsoiled gave a crop of 5278 pounds. This is an apparent increase of 23 per cent as the result of subsoiling.

A second trial made in the same way with four plots gave

| Plot. | Treatment. |      |
|-------|------------|------|
| 1     | Plowed     | 2340 |
| 2     | Subsoiled  | 2300 |
| 3     | Plowed     | 1470 |
| 4     | Subsoiled  | 1956 |

The average of the plowed plots is 1905 pounds and of



the subsoiled 2128 pounds, being a difference of 12 per cent in favor of the subsoiled.

The average of the whole ten tests is 18 per cent gain in weight of the crop as the result of subsoiling.

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### B—SUGAR BEETS IN COLORADO IN 1899.

The results of the experiments with sugar beets in 1897 and 1898 have already been published in former bulletins of this Station. In 1899 the work was not conducted on so large a scale. It was considered that the results of 1898 showed beyond a shadow of a doubt that there were large areas in Colorado that were adapted to the raising of large crops of excellent beets for factory use and that therefore there was no further need of making general distributions of seed for testing this point.

The questions to be considered hereafter are the more special points of how to handle the crop to get the best results. The season of 1899 was devoted to the study of questions concerning the proper time to plant, the best distance between the rows and whether or not the seed should be irrigated at the time of planting. With regard to the first, the results are decisive and that question may be considered as settled. The second was decided, so far as the test went, but the problem is yet left of still closer distances. The third problem was not solved and it remains as one of the two large problems yet to be attacked in Colorado. The solving of either would mean a gain of more money each year to Colorado than the total received from the government for carrying on experimental work. The first problem, broadly stated, is: How shall the irrigation water be handled to obtain a full stand of beets. The second problem is at the other end of the season: What can be done to make the beets ripen thoroughly?

#### I. TIME OF PLANTING.

Seed was sent to several parties representing the principal beet growing sections of the State with the request that they make four plantings conforming as nearly as convenient to the dates April 15, May 1, May 15 and June 1. The work was done on small plots so as to eliminate so far as possible differences of soil and irrigation and to allow the work to be done with great care. The returns show that the stand of beets was almost perfect in every case and that the crops were large in quantity and of good quality.

The first table gives the facts concerning the planting

and the second the returns of the harvest. The rows in each case were twenty-four inches apart. In this test and in all the others the seed was sent to the growers from the College and was in each case the Zehringen furnished by the Department of Agriculture at Washington.

RECORDS OF PLANTING.

| Name                         | Place             | DATE OF EACH PLANTING. |        |        |        | Date of harvest |
|------------------------------|-------------------|------------------------|--------|--------|--------|-----------------|
|                              |                   | First                  | Second | Third  | Fourth |                 |
| M. D. Parmenter.....         | Lamar.....        | April 10               | May 1  | May 15 | June 1 | Nov. 10         |
| C. H. Miller .....           | Antlers.....      | " 26                   | " 5    | " 20   | " 1    | " 20            |
| H. T. Gravestock .....       | Canon City.....   | " 20                   | " 3    | " 15   | " 1    | Oct. 31         |
| C. H. Gravestock .....       | " .....           | " 20                   | " 3    | " 15   | May 31 | Nov. 2          |
| J. M. Mortimer .....         | " .....           | " 15                   | " 1    | .....  | .....  | Oct. 29         |
| Adam May.....                | Debeque .....     | " 15                   | " 1    | " 15   | June 1 | Nov. 13         |
| Martin Nelson.....           | Greeley.....      | " 24                   | " 5    | " 20   | " 10   | Oct. 31         |
| I. W. Clapper.....           | Loveland.....     | " 20                   | " 10   | " 20   | " 10   | Nov. 10         |
| F. Niemeyer .....            | Evans .....       | " 20                   | " 5    | " 20   | " 10   | Oct. 24         |
| D. G. Edgerton .....         | Carbondale.....   | " 20                   | " 10   | " 20   | " 10   | Nov. 9          |
| Arkansas Valley Substation.. | Rocky Ford.....   | " 17                   | " 2    | " 16   | May 31 | Oct. 21         |
| Agricultural College.....    | Fort Collins..... | " 18                   | " 10   | " 26   | .....  | " 21            |
| Average .....                | .....             | April 19               | May 5  | May 18 | June 4 | Nov. 4          |

RECORDS OF HARVESTING.

| Name                            | Place             | WEIGHT OF CROP IN TONS PER ACRE FOR EACH PLANTING. |        |              |        |
|---------------------------------|-------------------|----------------------------------------------------|--------|--------------|--------|
|                                 |                   | First                                              | Second | Third        | Fourth |
| M. D. Parmenter.....            | Lamar.....        | 39.9                                               | 30.2   | 33.6         | 27.8   |
| C. H. Miller.....               | Antlers.....      | 9.3                                                | 10.2   | 9.9          | .....  |
| H. T. Gravestock.....           | Canon City.....   | 23.5                                               | 24.7   | 12.2         | 12.6   |
| C. H. Gravestock.....           | " .....           | 11.8                                               | 17.5   | 10.9         | 10.2   |
| J. M. Mortimer.....             | " .....           | 27.7                                               | 13.6   | Did not grow |        |
| Adam May... ..                  | Debeque.....      | 30.3                                               | 29.2   | 28.1         | 24.5   |
| Martin Nelson.....              | Greeley.....      | 27.0                                               | 23.8   | 10.9         | 9.5    |
| I. W. Clapper.....              | Loveland.....     | 27.2                                               | 17.0   | 8.7          | 5.6    |
| F. Niemeyer.....                | Evans .....       | 65.3                                               | 54.4   | 43.5         | 32.6   |
| D. G. Edgerton.....             | Carbondale .....  | 13.3                                               | 8.7    | 8.0          | 8.6    |
| Arkansas Valley Substation..... | Rocky Ford.....   | 15.2                                               | 16.6   | 26.0         | 18.9   |
| Agricultural College.....       | Fort Collins..... | 23.8                                               | 20.9   | 22.7         | 20.0   |
| Average 12 trials.....          | .....             | 26.2                                               | 22.2   | .....        | .....  |
| Average 10 trials.....          | .....             | 27.7                                               | 24.3   | 20.4         | 15.3   |



The results are surprisingly conclusive. They show in the strongest manner the advantage of early planting. And by early planting as used here is meant very early planting, much earlier than has heretofore been considered safe.

From the financial side no argument could be stronger in favor of early planting than these results. The planting of April averages 27.7 tons per acre, with a steady decrease to 15.3 tons for the first of June. It has usually been considered that from May 10 to May 20 was the best time to plant beets in Colorado. The difference between the first and third plantings is 7.3 tons per acre, which means a loss of \$31.00 per acre by the late planting.

The results at Fort Collins show strikingly how much cold the sugar beet plant can stand and thrive. The first planting was made April 18. The ground was in fine moist condition from a heavy rain and the beets germinated at once. The nights were cold, i. e. below freezing, until April 24; then followed a week of warm weather with four frostless nights. The first week in May was cold and on May 4, the temperature fell to nine degrees below freezing. The beets were not at all injured by the cold and made the most nearly perfect stand and the largest crop of all the different plots grown on the farm that year.

Such a test as this is not complete until it is known whether or not the date of planting has influenced the quality of the beet either in sugar or purity.

Through the courtesy of the Division of Chemistry of the Department of Agriculture at Washington, most of the analyses of the beets were made by them. The beets were carefully wrapped in oiled paper and sent by mail. In several cases the beets were weighed before sending and then weighed in Washington before analyzing to determine the amount they had dried out. The loss was surprisingly small. The average was less than three per cent of shrinkage. The analyses are given as made on the samples as they were analyzed at Washington and are therefore this small amount, about one thirtieth, too high. We are indebted to the Colorado Sugar Co., of Grand Junction, Colorado for the analyses of nearly a hundred samples of beets grown on the College Farm at Fort Collins. In these cases the shrinkage in shipping the samples was very carefully noted and the analyses, as given later, are all corrected to indicate the condition of the beets when harvested.

RECORDS OF ANALYSES.

| Name                  | Place          | PLANTING.           |        |                     |        |                     |        |                     |        |
|-----------------------|----------------|---------------------|--------|---------------------|--------|---------------------|--------|---------------------|--------|
|                       |                | First               |        | Second              |        | Third               |        | Fourth              |        |
|                       |                | Sugar<br>in<br>beet | Purity | Sugar<br>in<br>beet | Purity | Sugar<br>in<br>beet | Purity | Sugar<br>in<br>beet | Purity |
| M. D. Parmenter.....  | Lamar .....    | 11.2                | 75.7   | 14.0                | 79.9   | 10.5                | 71.9   | 13.1                | 76.7   |
| C. H. Miller .....    | Antlers.....   | 14.5                | 79.3   | 14.1                | 77.9   | 15.8                | 82.2   | .....               | .....  |
| H. T. Gravestock..... | Canon City.... | 17.5                | 84.0   | 20.3                | 88.4   | 19.6                | 86.9   | 20.5                | 90.8   |
| C. H. Gravestock..... | " .....        | 19.4                | 88.3   | 18.6                | 89.1   | 19.5                | 90.3   | 17.1                | 85.3   |
| J. M. Mortimer... ..  | " .....        | 16.3                | 84.3   | 17.9                | 85.1   | .....               | .....  | .....               | .....  |
| Adam May.....         | Debeque .....  | 12.4                | 76.5   | 14.3                | 82.9   | 13.6                | 77.7   | 13.6                | 78.6   |
| Martin Nelson .....   | Greeley .....  | 17.0                | 84.0   | 15.1                | 83.3   | 16.7                | 85.9   | 16.2                | 86.7   |
| J. W. Clapper .....   | Loveland.....  | 14.2                | 84.2   | 16.0                | 82.8   | 16.3                | 85.1   | 13.6                | 76.5   |
| F. Niemeyer.....      | Evans .....    | 13.8                | 81.0   | 14.2                | 83.7   | 14.3                | 78.9   | 16.6                | 85.8   |
| D. G. Edgerton .....  | Carbondale.... | 14.7                | 83.3   | 15.1                | 85.0   | 15.2                | 86.5   | 14.1                | 84.1   |
| Average .....         | .....          | 15.2                | 82.1   | 15.96               | 83.8   | 15.7                | 82.4   | 15.6                | 80.6   |

It will be noticed that there is scarcely any difference in the average analysis of the crops from the different plantings.

The second planting averages a trifle the best in both sugar and purity, but not anywhere near enough to offset the much larger yield of the earlier planting.

It can be said that taking into account all the factors of the problem there is a decided advantage in early planting; it gives a better stand, produces a larger crop and this crop is of good quality in sugar and purity.

For the sake of convenience in thinning the beets it is not advisable to plant all the crop at one time. The best way is to plant a third of the ground as early as possible, as early as one can be sure of water to irrigate up the seed if necessary and as soon as it seems warm enough to germinate the seed. Then put in the second third as soon as the first planting appears above the ground and the last within the next ten days.

2. DISTANCE BETWEEN ROWS.

Where sugar beets are raised by the natural rainfall it is customary to plant the rows as close together as it is possible to get a horse through them to cultivate. The present writer has seen a hundred acre field of beets in



Nebraska where the rows were but fourteen inches apart. Many experiments have shown that a sugar beet to do its best needs one square foot of ground. If then the rows could be made twelve inches apart and the beets thinned to twelve inches in the row we should have the largest possible crop per acre of the highest sugar and purity.

Where the beets are raised by irrigation the rows must be far enough apart to allow an irrigating furrow to be run between. It will not do to allow the water to run against the beet itself, because it injures the crown of the beet and lowers the sugar and purity. The water must be kept in the furrows and the sides of the furrow made high enough to carry the water over any small irregularities in the surface, the water soaking sideways through the ground to the beet. If the surface of the land was an absolute plane, a furrow three or four inches deep would be an abundance and such a furrow could be made in rows eighteen inches apart. In our tests on the College farm we have grown many fields of beets successfully in eighteen inch rows where the land was in the best possible condition. But where the land is not properly smoothed, an eighteen inch space is not enough to throw up a furrow high and deep enough to keep the water off the beets. Under most conditions, with gently sloping or nearly flat ground and long rows, twenty-four inches apart is none too much for ease in irrigating. The twenty-four inch row will not raise so large a crop per acre as the eighteen inch row.

A set of experiments was made to determine whether it is possible to get the benefit of the large space for furrowing and irrigating while at the same time obtaining as large a crop as would be gotten from rows close together. The rows were planted alternately eleven and twenty-seven inches apart. All the irrigating was done in the twenty-seven inch space, while the beets on the two sides of the eleven inch space were so near together that after the thinning and the first hoeing, they shaded this small space and it required no further attention. The two rows together occupied thirty-eight inches, an average of nineteen inches per row. These plots were planted side by side with those in which all the rows were twenty-four inches apart and which were irrigated between each row. This second method, and also the method of eighteen inch rows, require twice as many irrigating furrows as the twenty-seven and eleven inch furrows.

The results are given below.

DISTANCE BETWEEN ROWS.

| Name                         | Place              | WEIGHT, CROP, TONS PER ACRE. |                             |
|------------------------------|--------------------|------------------------------|-----------------------------|
|                              |                    | Rows 24 inches apart         | Rows 27 and 11 inches apart |
| M. D. Parmenter.....         | Lamar.....         | 30.9                         | 40.8                        |
| C. H. Miller .....           | Antlers.....       | 10.2                         | 13.8                        |
| H. T. Gravestock.....        | Canon City.....    | 25.1                         | 26.4                        |
| C. H. Gravestock .....       | “ .....            | 14.2                         | 14.3                        |
| J. M. Mortimer.....          | “ .....            | 13.6                         | 24.8                        |
| Adam May.....                | Debeque .....      | 27.6                         | 35.8                        |
| Martin Nelson.....           | Greeley.....       | 25.5                         | 31.2                        |
| I. W. Clapper.....           | Loveland.....      | 15.1                         | 13.6                        |
| F. Niemeyer .....            | Evans .....        | 54.2                         | 66.0                        |
| D. G. Edgerton.....          | Carbondale.....    | 9.8                          | 13.2                        |
| Arkansas Valley Substation.. | Rocky Ford.....    | 16.8                         | 17.8                        |
| Agricultural College.....    | Fort Collins ..... | 19.8                         | 22.1                        |
| Average .....                | .....              | 21.9                         | 26.71                       |

The results are strongly in favor of the twenty-seven and eleven inch rows. It is not claimed that this method will give a larger yield per acre than all eighteen inch rows, but it is believed that it will give just as large a yield and can be profitably used on ground where it would be very difficult to use the eighteen inch row. The twenty-seven inch row is so wide that it allows an abundance of space to put in a big furrowing plow, use a good head of water and run a given stream a long distance—in other words, do a good thorough job of irrigating.

3. IRRIGATING THE SEED.

This is the most troublesome problem before the Colorado sugar beet raiser at the present time. If all seasons were the same in the rainfall, the problem would soon be solved. The years 1894 and 1900 show the possible extremes in this matter. In 1894 wheat that was sown the fall before did not germinate until the ground was irrigated the last week in May, and yet, wheat requires much less moisture to germinate than beet seed. In 1900 the month of April was as wet out here in the arid region as it usually is along the Atlantic or Gulf coasts. The ground was too



wet to be worked, and the beets put in the first week of May made an absolutely perfect germination without irrigation.

The year 1899 may be considered a fairly normal year for the earlier plantings and rather dry for the later. The tests of irrigating up the seed were made about the first of May, when the conditions were not far from an average. The plots were all planted on ground that had not been irrigated, and then half of them were allowed to depend on rain for the water necessary to germinate the seed, while the other half was irrigated the same day the seed was planted.

The following table shows the results of the two methods:

IRRIGATING THE SEED.

| Name                            | Place             | WEIGHT, CROP, TONS PER ACRE. |                                |
|---------------------------------|-------------------|------------------------------|--------------------------------|
|                                 |                   | Seed irrigated at planting   | Seed not irrigated at planting |
| M. D. Parmenter.....            | Lamar .....       | 35.3                         | 36.5                           |
| C. H. Miller.....               | Antlers.....      | 12.0                         | Did not grow                   |
| H. T. Gravestock.....           | Canon City.....   | 27.8                         | 23.7                           |
| C. H. Gravestock.....           | " .....           | 16.3                         | 12.2                           |
| J. M. Mortimer.....             | " .....           | 19.2                         | Did not grow                   |
| Adam May.....                   | Debeque .....     | 32.6                         | 30.7                           |
| Martin Nelson.....              | Greeley.....      | 26.2                         | 30.5                           |
| I. W. Clapper.....              | Loveland.....     | 15.0                         | 13.8                           |
| F. Niemeyer.....                | Evans .....       | 59.9                         | 59.0                           |
| D. G. Edgerton.....             | Carbondale .....  | 11.2                         | 11.8                           |
| Arkansas Valley Substation..... | Rocky Ford.....   | 17.8                         | 16.9                           |
| Agricultural College.....       | Fort Collins..... | 22.3                         | 19.6                           |
| Average .....                   | .....             | 26.3                         | 25.4                           |

Although the general average is in favor of irrigating up the seed, the figures of the individual plots show some for and some against it. There seems a probability that no uniform rule will apply to the whole of Colorado, but it is safe to make this a rule. Prepare for irrigation at time of planting; if within five days after planting, the seed shows no signs of swelling and sprouting, turn on the water and keep the ground wet until the plants show a full stand.

#### 4. VARIETY TESTS.

Four varieties of sugar beets were grown on the College

farm in 1899 and all four were grown both on a heavy clay soil and a clay loam. The records of the harvest and analysis are given below. The Zehringen and the Vilmorin No. 1, were sent by the Department of Agriculture at Washington, while the Vilmorin No. 2 and the Kleinwanzlebener were furnished by the Oxnard Sugar Co., of Norfolk, Nebraska.

All the samples were taken October 21.

VARIETY TESTS.

| Variety                | Crop per<br>acre<br>Tons | Total<br>Solids | Sugar in<br>juice | Purity |
|------------------------|--------------------------|-----------------|-------------------|--------|
| Heavy clay soil -      |                          |                 |                   |        |
| Zehringen.....         | 22.2                     | 18.74           | 14.55             | 77.5   |
| Vilmorin No. 1.....    | 20.9                     | 20.21           | 16.29             | 80.8   |
| Vilmorin No. 2.....    | 20.4                     | 18.69           | 15.03             | 80.2   |
| Kleinwanzlebener ..... | 17.9                     | 18.67           | 13.73             | 73.6   |
| Clay loam -            |                          |                 |                   |        |
| Zehringen.....         | ....                     | 18.18           | 15.75             | 86.8   |
| Vilmorin No. 1.....    | ....                     | 17.55           | 14.33             | 81.7   |
| Vilmorin No. 2.....    | ....                     | 18.85           | 16.38             | 86.9   |
| Kleinwanzlebener ..... | ....                     | 17.61           | 14.07             | 79.9   |

Analyses were made of the beets from the different plots grown on the College farm in 1899 and are given below. The variety used in each case was the Zehringen sent by the Department of Agriculture at Washington.

| Date of planting | Remarks                                  | Crop<br>per<br>acre<br>Tons | Total<br>Solids | Sugar<br>in<br>juice | Purity |
|------------------|------------------------------------------|-----------------------------|-----------------|----------------------|--------|
| April 18.....    | 24 inch rows, not irrigated.....         | 23.8                        | 18.59           | 14.86                | 78.0   |
| May 4.....       | " " " " .....                            | 22.2                        | 18.74           | 14.55                | 77.5   |
| " 10 .....       | " " " " .....                            | 20.9                        | 17.86           | 14.74                | 82.6   |
| " 10.....        | " " " " .....                            | 18.7                        | 17.64           | 14.00                | 79.4   |
| " 10.....        | " " irrigated.....                       | 20.9                        | 17.74           | 14.28                | 81.4   |
| " 10.....        | 27 and 11 inch rows, not irrigated ..... | 20.5                        | 17.58           | 14.06                | 80.2   |
| " 10.....        | " " " irrigated .....                    | 23.7                        | 18.57           | 14.87                | 80.3   |
| " 10.....        | 24 inch rows, seed soaked.....           | 24.5                        | 17.57           | 13.75                | 78.2   |
| " 10.....        | " " half the seed soaked.....            | 27.5                        | 17.96           | 14.19                | 80.1   |
| " 26.....        | " " not irrigated.....                   | 15.3                        | 16.18           | 12.62                | 78.0   |
| " 26.....        | " " irrigated.....                       | 22.7                        | 17.08           | 13.78                | 80.5   |



5. SUMMARY OF BEET TESTS, 1899.

Different dates  
of planting.

|               |                    |
|---------------|--------------------|
| April 19..... | 20.7 tons per acre |
| May 5.....    | 24.3 " " "         |
| May 18.....   | 20.4 " " "         |
| June 4.....   | 15.3 " " "         |

|          | Sugar in beet.<br>Per Cent. | Purity.<br>Per Cent. |
|----------|-----------------------------|----------------------|
| April 19 | 15.2                        | 82.1                 |
| May 5    | 15.9                        | 83.8                 |
| May 18   | 15.7                        | 82.4                 |
| June 4   | 15.6                        | 80.6                 |

Distance  
between rows.

|                       |                    |
|-----------------------|--------------------|
| 24 inches.....        | 23.7 tons per acre |
| 27 and 11 inches..... | 28.1 " " "         |

Irrigating  
up the seed.

|                                          |                    |
|------------------------------------------|--------------------|
| Irrigated, all grew.....                 | 26.3 tons per acre |
| Not irrigated, two failed, the rest..... | 25.4 " " "         |





Bulletin 58.

August, 1900.

# The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

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## A SOIL STUDY.

PART II.

# The Crop Grown: SUGAR BEETS

—BY—

WILLIAM P. HEADDEN.

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Fort Collins, Colorado.

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# A SOIL STUDY:

## Part II.\* The Crop Grown: SUGAR BEETS.

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### INTRODUCTORY.

#### PREVIOUS WORK OF THE STATION ON SUGAR BEETS.

§ 1. This Station has already published nine bulletins on the subject of sugar beets, seven of which have been devoted to the demonstration of the fact that remunerative crops of sugar beets can be grown in the irrigated sections of this State up to altitudes of 7,800 feet. The earliest experiments recorded, 1888, show a trifle over 12 per cent. of sugar as the maximum per cent. present in any of the varieties experimented with. The only object aimed at in the experiments of that year seems to have been to determine whether the beet could be successfully cultivated under our conditions. The results were most encouraging, both in regard to the percentage of sugar present in the beets and also the tonnage, which ranged from 24 to 30 tons per acre. This yield was estimated from the product of an average row 450 feet long.

§ 2. The experiment of 1888 was not continued in 1889, but another line of work was undertaken, namely, to study the effect of various soils upon the composition of the ash, the percentage of the sugar, and on the feeding value of the beets. The results of this investigation were published in 1890 as Bulletin 11.

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\* Part I., forming Bulletin 46 and issued in 1898, is out of print. Most of the reports of the Station have something about sugar beets. Of the bulletins treating of sugar beets, none but 36, 51 and 57 can be supplied, except to libraries. Those printed are as follows:

7. Potatoes and Sugar Beets. April, 1889. Profs. Cassidy and O'Brine.
11. Sugar Beets. April, 1890. Director Ingersoll and Dr. O'Brine.
14. Progress Bulletin on Sugar Beets. January, 1891. Dr. O'Brine.
21. Sugar Beets; Potatoes; Fruit Raising. October, 1892. F. L. Watrous.
36. Sugar Beets. March, 1897. Prof. Cooke and Dr. Headden.
42. Sugar Beets in Colorado in 1897. February, 1898. Prof. Cooke and Dr. Headden.
46. A Soil Study. Part I. The Crop Grown: Sugar Beets. June, 1898. Dr. Headden.
51. Sugar Beets in Colorado in 1898. March, 1899. Prof. Cooke.
57. Farm Notes. Alfalfa; Corn; Potatoes; Sugar Beets. July, 1900. Prof. Cooke.
58. A Soil Study. Part II. The Crop Grown: Sugar Beets. August, 1900. Dr. Headden.

§ 3. During the season of 1890, Pres. Ingersoll, who was the Director of the Station, and Dr. O'Brine, Professor of Chemistry, joined in a study of the general condition and outlook for the beet sugar industry; while the Horticultural and Chemical Departments cooperated in further study of the sugar beet. The specific subjects with which they experimented during this season being a study of the effect of the distance between the beets in the row upon the amount of sugar contained in the beets, and of the relation between the size of the beet and its sugar content.

§ 4. A number of persons had, by this time, become sufficiently interested in the subject to grow sugar beets and send them to the Station for analysis. The descriptions of the samples, as received at the laboratory, were very imperfect, as was to be expected, but the results obtained fully justified the conclusion of Bulletin 14, which I can do no better than to quote:

We believe that it has been established that the soil and climate of Colorado are favorable to the production of sugar beets, and that they can be successfully and profitably raised to the advantage, both of the farmer and manufacturer.

§ 5. Experiments were continued during the years 1891 and 1892, not only by the Station at Fort Collins, but also at the Substations in the San Luis Valley, Arkansas Valley and the Divide, also by individuals in the Arkansas Valley and in the neighborhood of Fort Collins. The chief importance seems to have been attached to the endeavor to determine how much irrigation is required to produce the best results, and to notice the effects of both too little and too much irrigation upon the crop, and the percentage of sugar in the beet. The effect of the distance between the beets in the row was also studied, but was subordinated to the questions of irrigation and cultivation. The results obtained at the Arkansas Valley Substation at Rocky Ford during these years, 1890 to 1892, were published in Bulletin 21, October, 1892. The rest of the results were not published until March, 1897, in Bulletin 36, which contains a succinct statement of the results recorded up to that date; some of which, about one third, had not been published in any previous bulletin.

§ 6. In the spring of 1897 the public seemed sufficiently interested to justify the Station in again taking up the subject, and having received quantities of seed from the Department of Agriculture at Washington, and also from other sources, it was distributed to persons in different sections of the State, together with explicit instructions how to plant, to cultivate, and especially how to harvest the samples for analysis. The results obtained were, more satisfactory data concerning the time of planting, cultivation and harvesting of the crop. In addition to this, experiments were made at a greatly increased number of localities throughout the State. In



other words, the experiments were greatly multiplied and made simultaneously. So far as quantity and quality of crop was concerned, we only corroborated the results of previous years, *i. e.*, that the soils of Colorado produce beet crops which compare favorably with those produced elsewhere, where the beet sugar industry has proved a profitable venture. There was added to this the results of a study of the conditions at and around the beet sugar factories of Nebraska, Utah and New Mexico, making the statement of facts concerning this industry as complete as possible, and giving the public the fullest possible data wherefrom to draw their own conclusions as to the advisability of engaging in this industry.

§ 7. At this time, the season of 1897, the Department of Chemistry began an independent investigation, whose principal object was a study of the chemistry of the crop as affected by an alkalized condition of the soil. This work traversed a number of questions pertaining to the crop in a fuller and more systematic manner than had previously been done. The sugar in the beets was determined weekly, beginning September 2, and continued until October 13, when the crop was harvested; and from time to time till January 8, 1898, in beets left in the ground and covered with straw to protect them against severe freezing. This gave us data respecting the effect of alkali upon the amount of sugar present and its effect upon the time of maturing; the composition of the ash at various periods of growth, the distribution of both sugar and ash constituents in the beet, the composition of the beets and leaves in regard to their feeding value, the total dry matter in the leaves and roots, its quantity in the respective thirds of the latter, etc. The results of this year's work are contained in Bulletin 46. In 1897 the Station carried on two lines of experimentation with sugar beets, one economic and the other almost purely chemical, resolving itself into a soil study, which it was intended to be.

The work was continued in 1898 and 1899. Some of the results of 1898 have already appeared as Bulletin 51. This consists of more extended experiments upon the effects of the date of planting, methods of planting, time of thinning, distance between plants in the row, experiments with varieties, and a comparison of home grown and imported seed in regard to the quality of the beets produced.

§ 8. The following pages record the further observations made during the years 1898 and 1899, being, in fact, a continuation of Bulletin 46, and for that reason a few of the conclusions of that bulletin are reproduced here:

The effect of the alkali, present in our soil, upon the sugar content of the beet is not, of itself, detrimental.

The maturing, or ripening, of the crop corresponds to an increase of from 2 to 3.5 per cent. of sugar in the beet, and about one third of the total yield of sugar.

The rate of drying out of beets is about 5 per cent. for the first 24 hours, but by the end of five days it falls to about 2 per cent. and remains practically constant for the next twelve days.

The weight of the leaves of Colorado grown beets equals about 87 per cent. of the weight of the roots. The weight of the leaves does not increase materially during the last six weeks of the growing season, but during this time the weight of the root increases by 64 per cent. of its weight at the beginning of the period, or 39 per cent. of the weight of the mature beet.

The presence of alkali increases the weight of the leaves very slightly, but has no marked influence on the date of maturing.

As the sugar is formed there is a disappearance of dry matter, other than sugar, in the beet, suggesting the formation of the sugar in the root by the transformation of substances already deposited therein.

The effect of alkali upon the percentage of ash in the roots is to increase it by about 2 per cent., reckoned on the dry matter.

The composition of the ash of the beets seems not to have been affected by the different character of the soils experimented with, either because there was so great an abundance of available, and to the plant, acceptable, mineral matter present that it was not affected by the presence of a large quantity of other salts, or the composition of the ash of the sugar beet is very constant. I think that the latter is the case. The composition of the ash is represented by the following approximate percentages: Sulphuric acid, 3.5; phosphoric acid, 7-9; alkalies, 48-52; lime, 2-3; magnesia, 6; chlorin, 11.50-14.50; carbon dioxid, about 15.

The ash of the beet leaf has a general composition which, like that of the beet, is the same throughout the season, except that there is an increase in the chlorin as the plant approaches maturity.

§ 9. The trials in different parts of the State in 1897 aroused sufficient interest in the possibilities of the sugar industry in Colorado, for the resources of the Station to be supplemented by aid from the United States Department of Agriculture, from the Chamber of Commerce of Denver, and from various counties in the State. This aid was largely given through the solicitation of the Chamber of Commerce, and was principally in form of prizes to induce growers to compete for good results. The field trials were directed by Prof. W. W. Cooke. Over 800 analyses were made by the Station. The results of these tests, together with the study of the best methods of growing sugar beets, is given in Bulletin 51.

§ 10. Some additional tests on methods of cultivation, dates of planting, distance between rows, and irrigating the seed are given in Farm Notes, Bulletin 57, by Prof. W. W. Cooke. These are the results of cooperative trials with growers in different parts of the State. The same bulletin reported the results of the tests made throughout the State in cooperation with the Department of Agriculture and the Chamber of Commerce.



## THE CHEMICAL WORK OF 1898 AND 1899.

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### DESCRIPTION OF THE CONDITIONS.

§ 11. The plot on which the beets were grown in 1898 was the same as that used in 1897. The character of this plot having been fully described in Bulletin 46, p. 5, it will not be repeated in this place. The cultivation of the preceding season and the effects of the soil remaining thrown up in ridges over winter, exposing it to the weathering action of the season, tended to better its mechanical condition. This was, as I stated in Bulletin 46, the result most desired in order to reduce our study to the question of the effect of the alkali upon the crop. In addition to the weathering, effected as above stated, I endeavored to further modify the mechanical condition by the application of manure and straw. The plot was divided into sections one hundred feet long and twenty-five feet wide; alternate sections received an application of manure at the rate of sixty-four tons to the acre, and one section of the plot, the most difficult one to handle, received a dressing of cut straw at the rate of fourteen tons to the acre.

My object was twofold: First, to study the effect of the manure upon the soil; second, to observe its effect upon the crop.

The straw was used that we might be able to judge, in a measure at least, of the relative effect of the manure as a mechanical agent and as a fertilizer. The crop raised was, as in 1897, sugar beets, and we were successful in getting the same varieties, but the seeds were from different lots, for the crop of 1898.

The cultivation was similar to that received by the preceding crop, but having gotten rid of a patch of poverty weed on the south side of the plot, we were not troubled by insects to nearly the same extent as during 1897, still both of the beetles, *Systema taeniata* and *Monoxia puncticollis*, observed then, appeared again and did some damage. We, however, did not have recourse to the use of insecticides as in the preceding year. In our case we found that removing the poverty weed and keeping our crop well tilled sufficed to keep the beetles down to such an extent that the damage done by them was not serious.

The alkali appeared nearly as bad as heretofore, and we had trouble with the same sections that had previously given us trouble.

The corroding effects of the alkali was observed, but not to the same extent, and the spots of ground showing it were not so large as in 1897. There was a small spot in which but few seeds germinated; there seemed to be an abundance of moisture, the seed were found at a depth of an inch and a half, and the mechanical condition of the soil was good. This failure of the seed to germinate, for they did not come up at any time during the season, remains unexplained. It was observed that some beets in this part of the patch continued to come up for weeks after the first had made their appearance, especially after irrigation. It is very improbable that this was due to lack of moisture, for this was observed in a very wet portion of the patch, but not the wettest, nor indeed is it more strongly alkalized than some other parts of the plot. The analyses of the soils taken from these spots, and those of the ground waters also, show a larger amount of magnesia present than in other places within the plot; this is more markedly the case with the ground waters than with the soils. Experiments show that magnesian sulfate retards the germination of seeds, but neither the soil nor the ground water, nor yet the water-soluble portion of the soil, shows a sufficient quantity of magnesian sulfate to account for this. The inorganic substances present do not suggest any solution for the failure of the seed to come up.

#### THE WATER CONDITIONS.

§ 12. The ground was very wet in the spring, so much so that it caused a delay of two weeks or more in planting. The crop was not planted till June 4; some of it not till June 13. This, however, was not due to the condition of the soil. The only irrigation that we were able to give this crop was given from July 8 to 10, and this was with seepage water, of which we had only a scant supply, so scant that we could not obtain any sample of off-flowing water. But a few days later, a heavy rain having fallen in the mountains to the west of us, more than doubling the flow of the river, a large quantity of water was turned into the Larimer County Ditch No. 2 and its laterals. One of our dams was washed out and the lower portion of our beet plot flooded. This happened between the afternoon of the 13th and the morning of the 14th of July. The drains for receiving the off-flow water were immediately opened and the water turned out of the ditch. Samples of both on and off-flow water were taken. The patch drained rapidly, the surplus water being removed in about three hours. This was the only irrigation that the crop received. The total rainfall for the months of July, August, September and October was 2.8 inches. The total amount of water received by the crop, from the time of planting till harvested, was about eight inches. The ground was wet at the time of planting and the water plane was within less than two feet of the surface.



The level of the ground water fell about a foot in the next 30 days. The irrigation given from the 8th to the 11th was not sufficient to raise the level of the ground water quite as high as it was at the time of planting and it then fell rapidly, making a fall of almost exactly two feet in eleven days. This fall represents the rate of drainage and evaporation. The weather was hot and evaporation was rapid, but that drainage was active can scarcely be questioned. Especially so because the water level in the adjoining, and lower lying, land had not been raised and there was only our small and local supply of water to be removed.

The water level, at a point about two hundred feet to the east of my plot, was not at any time sensibly effected by the irrigation of my plot. The well, the measurements of which form the basis of this assertion, is not very far from an underdrain, perhaps 75 feet from it, but I do not think this fact has very much, if anything, to do with our failure to perceive any change in the level of the water in this well. I think it more likely that the amount of water used was simply insufficient to force its way so far through the soil.

§ 13. This is not the place I intended to discuss the question of water, further than to state the supply furnished to the crop, but it was observed that the different wells fell at very different rates. I have given the maximum fall for the eleven days immediately succeeding the 14th inst. From this date on the water plane fell slowly until it reached its greatest depth for the season during the first week of October. But during the next fourteen days it rose a foot, in some of the wells rather more.

§ 14. The water level at the lower end of the plot ranged, from the end of July to October 10, from 3 to 4.5 feet below the surface, and there were but few beets in this section, as was repeatedly noted in Bulletin 46, but at the western, or higher end, the water level was from 5.2 feet to 6 feet below the surface, and the crop was excellent. At an intermediate point we have the water level ranging, during this same period, from 3.5 to 4.5 feet, with an abundance of alkali and yielding a good crop. With a part of the facts before us it would be easy to justify the inference that beets will not grow where the water plane is from 3 to 4.5 below the surface, but in view of other facts, observed at the same time, we hesitate to offer any statement relative to the cause of the failure of the crop to grow in the section in question, either in regard to the alkali or the water.

§ 15. Notwithstanding the nearness of the water to the surface of the ground, the crop showed the need of water throughout the latter part of the season; our field notes showing that on July 22 the beets were wilted and the water plane low. The weather

was hot and the wilting may have been dependent upon this as much as upon a lack of water in the soil, but on August 13, it is remarked that the crop needs water and on the 17th the condition of the ground is designated as dry, though we had had in the meantime, August 4 and 5, a rain fall of 0.78 inch. The ground had been kept as mellow as possible and free from weeds, having received, in all, five cultivatings and five hoeings.

§ 16. There was no need of irrigating the plot during the season of 1899, though we gave it a thorough soaking from August 31 to September 2, not because the crop needed it, but for the purpose of puddling the ground and of studying the changes which took place in the water by its contact with the soil.

§ 17. The chief cause of our abundance of water was the fact that we received a sub-irrigation July 1 to 7, coming from the western part of the farm. There is a drain immediately west of my plot which should have taken off the greater part of this underflow, but it did not prevent my plot being filled nearly to the surface with water. The water plane being raised to within 18 inches of the surface, as was proven, not only by the water in the wells, but also by several holes dug in order to verify this observation. This development was something entirely new. I knew that the stratum of gravel underlying the plot was filled with water and that there was probably a flow to the eastward through it. I thought that it came from a more distant source, believing that we were fully protected against sub-irrigation of this sort by a ditch constructed to utilize the seepage water gathered for a mile or more to the westward of us, and further, by the drain alluded to. I believe that these two really gather all the water that, under ordinary conditions, drains from the higher land to the westward of us, but in this instance an unusual supply of water enabled the Farm Department to run water night and day for a week, with the result that the water found its way down into and filled up my lower lying land. The wetness of the land interfered with the cultivation of the crop, but the mechanical condition of the soil was greatly improved over that of the preceding seasons, so that the cultivation was much easier than in 1897 and '98.

§ 18. The ground was not disturbed after the irrigation of September 2, but it was allowed to bake and harden as much as it would. This crop was cultivated twice, hoed twice and irrigated once.

In 1898 the crop was irrigated but once, because we could not get water to irrigate with. This single irrigation was only a light one, applied July 8 to 10, and a part by accident on July 14. Subsequently the ground became very hard, in spite of our efforts to keep it mellow. In 1899 we sought to pack and allow it to be-



come hard and dry after the irrigation of September 2. The crop, taking the whole patch, was in 1898, 13 tons to the acre, and in 1899, 14.5 tons. I attribute the increased crops to the improvement in the condition of the soil and to a rather better stand, without considering whether this latter was due to the improved condition of soil or not.

#### THE EFFECT OF THE MANURE UPON THE STAND AND THE BEETS.

§ 19. The effect of the manure was very marked, improving the stand by at least 10 per cent. I believe that under ordinary conditions the effect of so heavy a dressing of manure would not be followed by an improvement in the stand, but in our case it was; the weather conditions turning favorable just after the planting.

The planting took place on May 11, followed by a rainfall of over 1.5 inches during the rest of the month, which was well distributed, rain falling on twelve of the remaining twenty days of the month. Had this not been the case, it is a question whether the manure might not have facilitated the drying out of the soil sufficiently to more than offset its stimulating effect upon the germination of the seed. As it was, the seed germinated better, the plants were more vigorous throughout the season, and the weight of the crop was greater; but the shape of the beets was inferior, very many of them being rooty, forming a chunky beet with a number of roots spreading out from it, literally covered with masses of fibrous roots. The ratio of tops to roots was not determined, but it was evidently higher than where no manure was used. The six plots used for manuring agreed fully in justifying the above statements. There is no reason to suppose that other conditions would have modified any of these results, except the one already mentioned as possibly exceptional, *i. e.*, that manuring improved the germination and stand. Our observations on the effect of coarse manure, under our conditions, leads to this doubt, which we would not otherwise entertain.

#### EFFECT OF THE MANURE AND ALKALI ON THE SUGAR IN THE CROP.

§ 20. In 1897 we found that the ripening of our crop, or better, that the formation of the sugar, was much more rapid between October 6 and 13, than at any other period during the season, either before or subsequent to this date. Our results showed that about one third of the sugar contained in the crop made its appearance during these seven days. As the crop of 1898 was later than that of 1897, both in planting and maturing, we did not attempt to follow the development of the sugar throughout the season, but contented ourselves with endeavoring to determine the effects of our alkali and manure upon the date and amount of sugar produced during the period of this maturing process. Our first samples were

accordingly taken on October 3. These were trial samples taken to help us in judging of the condition of the crop. We had already received a number of samples from the Farm Department, but these varied greatly, and we did not know from which of the different plots the sample had been taken. It was, furthermore, out of the question for us to take the plot most nearly representing the plot taken for comparison in 1897, for this plot had been hastened into ripening by lack of moisture. This was so pronounced, at this date, that the tops wilted to the extent of lying flat on the ground. The soil was dry to a greater depth than that reached in digging the beets. If there had been no other differences, these facts make it evident that we cannot compare these plots, so I shall use another whose history is as follows: In 1891 it received a dressing of manure, was planted to potatoes; 1892, trucked, not manured; 1893, fallow; 1894, rye, crop cut green and removed from plot; 1895-'96-'97, fallow; 1898, planted to beets but not manured. The varieties grown on this plot were Vilmorin Improved, White Imperial, White French and Dippe's Improved Kleinwanzlebener.

§ 21. In the following table we do not see the pronounced increase in the amount of sugar as the season advanced or the crop matured, as shown in the crop of 1897, but the season was very different. In 1897 we had, in the early part of September, enough rain, 0.74 of an inch, to stimulate the beets into an increased growth, after a period of comparative inactivity. This produced a material increase in the weight of the crop, but the relative quantity of sugar was less than before this period. The effect was noticeable for two and a half weeks or more, at the end of which period the sugar had increased again and reached its maximum for the season. In 1898 we had no such an abundance of water as in 1897. We were unable to irrigate more than once, and then far less copiously than in 1897, and the rainfall from August 6 to October 15, a period of 70 days, amounted to only 0.74 of an inch, which is the same amount that fell in four days, September 10 to 14, in 1897. The crop of 1898 received its moisture from the soil, developed continuously under very uniform conditions, and matured without showing a so uniformly large gain at the maturing period. In 1897 this amounted to from 2 to 3.5 per cent.; in 1898 the greatest gain for this period was 1.44 per cent. in two weeks. This observation is true in regard to the Farm plot as well as for our own. Furthermore, it is observable in the records of the Department that there is no such great increase in the percentage of sugar just at the time of ripening, unless the beets were already mature at the time of taking the first samples, which was not indicated by the department of the beets when grated, as the earlier samples became very black on being exposed to the air. The Department received a sample harvested September 27, 1898, original Kleinwanzlebener, which





contained 15.23 per cent. of sugar; a sample of the same variety, harvested November 2, contained 15.12 per cent. of sugar. These samples, harvested thirty-five days apart, show almost exactly the same percentage of sugar, and the coefficient of purity is also quite the same, *i. e.*, 83 and 81.

§ 22. The varieties grown by the Farm Department remained almost constant from October 3 to October 22, only one of the three varieties showing any material gain, and in this case a gain of only one per cent. I infer that this difference in the deportment of the crops of the two years was due entirely to the season, and not to either the cultivation or to the soils. There are three different soils and nine varieties of beets included in this comparison; five of the varieties of beets were grown on our alkali soil and the four others on two different soils. Our soil caused no deviation in this respect, and the conclusion of the preceding years, *i. e.*, that the alkalized condition of our soil produces no effect upon the development of the beet, is corroborated. The statement, however, that the maturing of the beet represents an increase, that is, a sudden increase, amounting to from 2 to 3.5 per cent., now seems to be an extreme variation. The following table showing the results obtained during the season of 1899 strengthen this view; the greatest increase being 1.1 per cent. from October 10 to 24, and we find no further change, though the experiments were continued until November 10:



TABLE II.—SUGAR IN THE MANURED AND NOT MANURED CROPS OF 1899.

| DATE.             | Number of Section. | (M) Manured.<br>(N) Not Manured. | Kleinwanzlebener.                |         |                               |                                    | Zehringen.                       |         |                               |                                    |
|-------------------|--------------------|----------------------------------|----------------------------------|---------|-------------------------------|------------------------------------|----------------------------------|---------|-------------------------------|------------------------------------|
|                   |                    |                                  | Percentage of Sugar<br>in Beets. | Purity. | Number of Beets in<br>Sample. | Average Weight of<br>Beets. Grams. | Percentage of Sugar<br>in Beets. | Purity. | Number of Beets in<br>Sample. | Average Weight of<br>Beets. Grams. |
| October 10 .....  | 1                  | M                                | 15.10                            | 79.4    | 12                            | 627.2                              | 14.25                            | 79.8    | 13                            | 760.0                              |
|                   | 1                  | N                                | 16.34                            | 82.4    | 12                            | 661.5                              | 14.06                            | 79.6    | 11                            | 688.1                              |
|                   | 2                  | M                                | 15.01                            | 82.9    | 14                            | 517.0                              | 12.83                            | 72.1    | 12                            | 680.4                              |
|                   | 2                  | N                                | 16.34                            | 81.5    | 12                            | 491.4                              | 16.06                            | 81.3    | 12                            | 456.2                              |
|                   | 3                  | M                                | 11.88                            | 74.5    | 14                            | 488.0                              | 11.97                            | 73.4    | 12                            | 712.3                              |
|                   | 3                  | N                                | 13.97                            | 82.0    | 12                            | 846.0                              | 14.92                            | 83.8    | 12                            | 610.0                              |
| Average.....      | ....               | M                                | 13.99                            | 78.9    | .....                         | 540.0                              | 13.01                            | 75.1    | .....                         | 714.0                              |
|                   | ....               | N                                | 15.55                            | 81.9    | .....                         | 666.3                              | 15.01                            | 81.6    | .....                         | 585.0                              |
| October 18 .....  | 1)<br>2)<br>3)     | M                                | 13.20                            | 77.7    | 29                            | 666.6                              | 12.83                            | 71.1    | 18                            | 710.5                              |
|                   | 1)<br>2)<br>3)     | N                                | 14.54                            | 78.8    | 18                            | 645.5                              | 15.10                            | 80.1    | 12                            | 583.5                              |
| October 24 .....  | 1                  | M                                | 15.44                            | 84.6    | 12                            | 532.6                              | 15.72                            | 81.7    | 12                            | 572.3                              |
|                   | 1                  | N                                | 15.58                            | 82.3    | 12                            | 615.8                              | 17.57                            | 89.1    | 12                            | 496.7                              |
|                   | 2                  | M                                | 15.96                            | 83.7    | 12                            | 473.1                              | 13.92                            | 78.0    | 12                            | 646.4                              |
|                   | 2                  | N                                | 15.58                            | 81.9    | 12                            | 587.2                              | 16.34                            | 84.2    | 12                            | 527.4                              |
|                   | 3                  | M                                | 13.77                            | 76.8    | 12                            | 588.2                              | 12.82                            | 73.3    | 12                            | 834.6                              |
|                   | 3                  | N                                | 14.87                            | 78.3    | 12                            | 728.3                              | 15.82                            | 80.2    | 12                            | 538.6                              |
| Average.....      | ....               | M                                | 15.06                            | 81.7    | .....                         | 531.3                              | 14.15                            | 77.7    | .....                         | 683.3                              |
|                   | ....               | N                                | 15.34                            | 80.8    | .....                         | 643.8                              | 16.24                            | 84.5    | .....                         | 517.6                              |
| October 27 .....  | 1)<br>2)<br>3)     | N                                | 14.06                            | 77.2    | 30                            | 676.1                              | 14.81                            | 78.7    | 30                            | 509.8                              |
| November 10 ..... | 1)<br>2)<br>3)     | N                                | 15.77                            | 82.0    | 15                            | 629.2                              | 15.86                            | 84.2    | 15                            | 543.5                              |

§ 23. The results of 1897, given on p. 13, Bulletin 46, and those of 1898 and 1899, given in the two preceding tables, but more especially the results of 1897 and 1898, because these are compared with beets grown on ground free from alkali and in good tilth, leave no doubt about the effect of alkali upon the quantity of sugar developed in beets grown on soils abounding in these salts; *i. e.*, they are not detrimental so far as the sugar and the coefficient of purity are concerned, nor does it effect the time of maturing.

## THE EFFECT OF THE MANURE.

§ 24. It is usually stated and generally accepted that land on which a crop of beets is to be grown should not receive a dressing of manure immediately before being planted, but that it should receive the manure and be planted to some other crop between the manuring and the planting to beets. As already stated, I manured my plot heavily, 64 tons to the acre, in February, plowed it under in May and planted it to beets. The primary object was to observe its effects on the soil, but it presents an excellent example of the effects of manure upon the crop. I have already mentioned the fact that its effect upon the stand and growth of the crop was evident, and the tables show its effect upon the percentage of sugar and the coefficient of purity. The average for the fifteen samples taken from manured plots on October 3, 1898, is 12.79 per cent. sugar in the beets, with a coefficient of 78.1; the average for the corresponding set from the unmanured plots is 13.30 per cent. sugar in beets, with a coefficient of 78.4; for the samples taken October 15 the averages are: 13.00 per cent. sugar, 79.3 purity, and 13.40 per cent. sugar, 79.6 purity; for October 22 we found 12.92 per cent. sugar, 80.8 purity, and 14.18 per cent. sugar and 83.9 purity. The averages are in harmony with our statement that manuring land immediately before raising a crop of sugar beets on it tends to lower both the sugar content and the coefficient of purity; but its range is only from 0.5 to 1.2 per cent. sugar and from 0.1 to 3.1 in purity, provided we attribute the whole of these differences to the effect of the manure.

§ 25. The effect upon the form of the beets was in our case a much more serious consideration than the diminution of the sugar content and the coefficient of purity. The form of the beets was decidedly objectionable. The bad tilth of the ground of itself tended to the production of ill shaped beets, but the manure made them very rooty, giving rise to a short, chunky beet with several spreading roots and a large mass of fibrous roots. This was very noticeable and common to all of the varieties, but shown in different degrees.

§ 26. The crop of 1899 shows the same results, but the manure, having become more fully incorporated with the soil, effected the form of the beets less than in the preceding year. The percentage of sugar and the coefficient of purity were effected quite as pronouncedly as in 1898. This is evident from the tabular statement of the results for 1899, from which it appears that the manure caused a depression of as much as 2.3 per cent. (See Zehringen, samples taken October 18.) The effects of the manure upon the stand, color of the tops and development of the crop, were almost as



evident in '99 as they were in '98. The residual value of the manure, judging by its effects upon the second crop, is greater than one would be justified in anticipating. This is largely due, without doubt, to the peculiar resistance to complete decay and humification shown by manures in our soils. It is an often observed fact that manure when applied to a tilled crop remains a long time in the soil without undergoing that disintegration which we are accustomed to see in Eastern soils, where there is an abundance of rain and cloudiness prevails for a much larger percentage of the time than with us. This fact was not new to me, but I was of the opinion that the soil, with the water level within from 4.5 to 3 feet of the surface, would remain moist enough, especially when shaded by the tops of the beets, to cause the complete rotting of the manure early in the season, but it was not so. The manure, some of it scarcely decomposed at all, was abundant when the beets were plowed out and can at the present time, two years subsequent to its application, be easily recognized as distinct from the soil. The practical recognition of this is the wasteful custom, still too general, of making no effort to convert the straw and other litter of the farm into manure, or of using the manure to fill mud holes in the roads or dumping it on the commons when it has become necessary to remove it from the neighborhood of the houses. It is a question with the ranchman how to treat the manure so as to get good results without materially adding to the labor of irrigation. This is especially true of cultivated crops. The beets did not produce shade enough to effect, even with the aid of the moisture in the soil, the rotting of the manure.

§ 27. The straw with which we dressed one section did not withstand decay so persistently as the manure. This may be explained by the fact that there was less of it, by its being loose, without any matting together, and by its having been more uniformly mixed with the soil.

§ 28. The effect of the straw upon the sugar content and coefficient of purity is not pronounced, but it is certainly less prejudicial than that of the manure. I cannot say that I observed any effect upon the form of the beets which I could attribute to the direct action of the straw. But its ameliorating effect upon the soil was quite as pronounced as that of the manure.

This is in harmony with the view expressed in Bulletin 46, *i. e.*, that the soil experimented with is so rich in plant food that the effect, if any, of the alkali upon the growth and composition of the crop is obscured, and that it is not the chemical composition but the mechanical condition of the soil which is the factor of greater importance in any endeavor to improve its condition. This statement would be of little importance did it not apply to all of

the alkali soils that I have seen in this State, which I firmly believe that it does.

§ 29. The numbers of the sections 1, 2 and 3 in the tables have the same signification as in Bulletin 46. Section 3 is described as in very bad condition and low, very wet and alkalized to such an extent that the surface becomes coated to the thickness of from one quarter to upwards of half an inch with alkali. Its condition is, in fact, so unfavorable that I have at all times questioned whether it is not rather to this, than to the alkali *per se*, that the difficulty of growing any thing in this section ought to be attributed. The alkali may be responsible in part for this condition, but there is no question in my mind but that the water is the direct cause of this to a greater extent than the alkali. The very great improvement caused by addition of the manure and straw to this soil is corroborative of this view. I see nothing in the addition of straw to modify in the least the effects of the alkali nor to diminish its quantity, but it does change the texture of the soil, permitting aeration and disintegration to a beneficial extent.

§ 30. The third crop grown on this section still leaves it somewhat doubtful whether we should charge any of the evil to the direct influence of the alkali. A few of the young plants were undoubtedly killed by it, but after they had become established it seemed to do them no injury. I believe it to be of far less injury than it is usually thought to be. Both the sugar content and coefficient of purity of samples taken from this section during the three seasons are slightly lower than in samples taken from the other two sections. There are exceptions to this statement, but they are not of sufficient importance, in number or degree, to cast any doubt on the fact that beets grown in this section are inferior to those grown on the other sections. They have, however, improved in quality during the three years. The average of all varieties grown in 1897 was 10.66 per cent. sugar in beet, with a coefficient of 73.3; in 1898, including both manured and not manured, the average was 12.68 per cent. sugar, 76.2 purity; and in 1899 the average was 14.13 per cent. sugar, 77.1 purity. This is a marked improvement in the quality of the beet. The figures represent the total improvement, including that due to the soil, to culture, and the differences in the season. The two latter are more important than we are at first inclined to think. A good year is a familiar expression, but its equivalent in tons of beets, or pounds of sugar, is a very indefinite notion, especially to those who use it most frequently. Though three years of observation is too brief a time to form an estimate of the seasonal influences on this crop. I am inclined to credit a large share of the improvement in the quality of the crops to this cause, and also something to the



differences in culture; but after making due allowance for these factors, there remains a decided improvement, due to the improved soil conditions, and, so far as I can now see, this improvement is wholly in its mechanical condition, brought about by the subsoiling, cultivation, manuring and by being left in ridges during the winter, exposing it to weathering. That it is not due to improved drainage is evident from facts which will be dwelt upon at a subsequent time.

§ 31. The important fact in this connection is simply this: That the water table has not been lowered, except temporarily by prolonged dryness or a lack of irrigating water.

In connection with this question, the influence of the height of the water table, an attempt was made to determine the capillary power of the soil. It was necessary to break up the natural compactness of the soil, so we passed it through a 40-mesh sieve and packed it as firmly as we could, by gentle tapping, into a glass tube,  $1\frac{1}{8}$  inches in diameter. Experimenting in this manner we found that the water had passed upward  $31\frac{1}{2}$  inches in seven weeks, and in one year and five months the soil was perceptibly moist at a distance of 45 inches from the water surface, and quite wet at 39 inches from the same. If these figures represent the value of capillarity in the soil in its natural, undisturbed condition, it would seem that our crops ought to have been pretty well supplied with water at all times, there being but a short time when the water level was more than 45 inches below the surface of the ground. The evaporation from the surface in the open field, exposed to a hot sun and the winds, is quite different from the evaporation from a small, shaded and protected surface, such as that exposed in my tubes. I have made no attempt to determine how much of a part this may play in my experiment; I simply acknowledge that it has something to do with it, and that is all.

§ 32. I was at one time quite doubtful whether there was any drainage at all out of the area which I was cultivating, and thought to test the question by introducing some lithia chlorid into one of the wells and observe how long it would require for it to make its appearance in the adjacent wells. Lithia had been looked for in the analysis of the residues obtained from the ground water, and reported as absent, so I thought that my plan was feasible; but on examining the water more carefully, using larger quantities, I found it present in easily detected quantities. I had samples of the residues from the ground water, obtained during the preceding eighteen months, and an examination of these showed this element to be present at all times. I do not know whether this is true of other soil waters in this region or not. It, however, rendered this means of detecting a flow of water through our plot inapplicable,

but a subsequent experiment showed that the water level is lowered, by drainage or otherwise, from 0.7 to 1.0 foot in about 36 days. Observations, in 1898, on the rate of the fall of the water level after having raised it by irrigating, showed about 40 days as necessary for a like fall, *i. e.*, from 0.7 to 1.0 foot, in the different wells. The lowest point the water plane has reached below the surface of the ground, at the east end of the patch, corresponding to section 3, at any time during the three years, was 3.29 feet, which is less than the value of capillarity in this soil. Under such conditions of moisture it would seem that, in some respects, it would be an advantage, rather than otherwise, to have a long dry season. Such seems to have been the case, but not more so with this plot than with others more favorably conditioned.

#### THE DRY MATTER IN THE CROPS.

§ 33. The average percentage of sugar present in the crop of 1898 was materially higher than in the crop of 1897, and the crop grown by the Chemical Department in 1899 was very rich in sugar. I have already stated that in the latter years there was a scarcity of water, and that the rainfall during the latter part of the seasons was small, so that the soil became dry to a depth exceeding the length of the beets. I believed that this had the effect of increasing the dry matter in the beet, just as drying out under any other conditions would have done, and would account, in part at least, for the higher percentage of sugar. Accordingly, samples were taken, thirteen in number, ranging in weight from 800 to 10,500 grams, and the dry matter determined. The results ranged, in 1898, from 18.63 per cent. to 25.62 per cent., with an average of 22.00 per cent., as against 17.39 per cent. in 1897, when the range was from 16.69 to 18.01 per cent. These figures represent four varieties and seventy-two beets. The highest average obtained in 1897 was for the Kleinwanzlebener and Vilmorin, six beets each, which gave 18.95 per cent. as the highest percentage of dry matter, showing that there was an average of 3 per cent. more dry matter present in 1898 than in 1897, or at least one sixth more. In 1899 we find an average of 22.76 per cent., or three quarters of one per cent. more than in 1898; but this is with two varieties only, the Vilmorin and Zehringen. We did not find any difference between the beets which had grown on manured or unmanured sections in this respect. There were variations, but they were not constant in either direction. I think that this difference of from 3 to 3.75 per cent. in the total dry matter is mainly due to the difference in the seasons.

#### THE DRYING OUT OF BEETS.

§ 34. During the season of 1898 we received a considerable number of samples from different parts of the State and the results



were uniformly high. An attempt was made to obtain the weight of the fresh samples, but it was very unsatisfactory. I was informed that it was impossible for many of the parties to obtain the weight of the samples sent with any degree of accuracy, and this must have been the case, for quite a number of the samples received weighed more by 250 grams than when they were mailed to us, from three to five days previously. Why the senders should give us such under weights is not easy to understand. In spite of these accidents, we obtained 336 samples which we considered usable, in estimating the deduction to be made from the average percentage of sugar found in order to approximate the actual percentage in the beets in a fresh condition. The amount of drying out was very varying, often evidently too low, and sometimes so high that the result obtained had to be rejected as improbable; but none of the low ones were rejected and are included in the 336 samples used. The correction to be applied as based on these is 1.49 per cent. These samples were all wrapped separately in paper and inclosed in a cotton sack or cloth. As the weights given by the senders were unsatisfactory, I repeated the experiments of 1897 with even more care, having regard to the temperature at which the room was kept during the time of the experiment. The mean temperature for September, during that portion of it in which we received samples, was  $61.3^{\circ}$ , and for October it was  $46.3^{\circ}$ , but the mean maximum was  $61.0^{\circ}$ . I endeavored to keep the room about  $60^{\circ}$ . I took 4,660 grams of beets and obtained the following results, the loss being expressed in percentage of weight at beginning of the twenty-four hours.

TABLE III.—SHOWING THE RATE OF DRYING OUT OF BEETS.

| <i>Days.</i> | <i>Weight.<br/>Grams.</i> | <i>Temperature<br/>of Room. Degrees.</i> | <i>Percentage<br/>of Loss.</i> |
|--------------|---------------------------|------------------------------------------|--------------------------------|
| —.....       | 4660.0                    | .....                                    | ....                           |
| 1.....       | 4460.0                    | 57-66                                    | 4.39                           |
| 2.....       | 4322.0                    | 56-62                                    | 3.08                           |
| 3.....       | 4182.0                    | 56-57                                    | 3.24                           |
| 4.....       | 4066.0                    | 57-62                                    | 2.77                           |
| 5.....       | 3915.0                    | 57-62                                    | 3.71                           |
| 6.....       | 3801.0                    | 57-62                                    | 2.91                           |
| 7.....       | 3695.0                    | 57-65                                    | 2.79                           |
| 8.....       | 3617.0                    | 60-60                                    | 2.11                           |
| 9.....       | 3547.0                    | .....                                    | 1.93                           |
| 10.....      | 3468.0                    | .....                                    | 2.23                           |
| 11.....      | 3391.0                    | 57-60                                    | 2.17                           |
| 12.....      | 3305.0                    | 60-67                                    | 2.42                           |

§ 35. The conclusion arrived at in 1897, was that the maximum loss was 5.4 per cent. for the first 24 hours, and that after a few days it fell to about 2 per cent. and remained quite constant up to 17 days. The experiment just recorded was made under similar conditions as those in 1897. The beets were covered with gunny sacking to protect them from light and to protect them from drafts

of air as much as possible. In 1897 the loss in the first 12 days varied from 30 to 33 per cent. of the original weight of the beets; in 1898 we obtain 29.00 per cent. loss, and after the first seven days the daily loss is roughly 2 per cent.

As but few samples received from different parts of the State were analyzed sooner than five days after being harvested, the deduction of one and one half per cent. on account of drying out is quite within reasonable limits, as according to the most favorable results obtained by experiment, a deduction of upwards of 2 per cent. would be allowable. Our own samples were analyzed within 24 hours after being taken and lost less, and tend to correct the error and justify us in taking the lower figure, 1.5 per cent.

§ 36. The importance of this is apparent if we consider the effect of it in stating the average percentage of sugar in the crop of 1898. We have 813 samples of this crop and the average of the analyses as made is 15.12 per cent., but allowing for the drying out by deducting 1.5 per cent., we have 13.62 per cent. as the average, which I believe is the nearest approach to the truth that we can make.

§ 37. The records of this department show that the average of all samples recorded from 1888 to 1896 inclusive, is 12.8 per cent., according to which the crop of 1898 was above the average.

§ 38. It should be remembered that the question of drying out is of much greater importance in considering small samples sent to the Station than it would be in samples taken from car-load lots sent to a factory. The factory sample would be likely to be nearer correct than the sample sent to some chemical laboratory to be tested.

#### COEFFICIENT OF PURITY.

§ 39. In connection with the last question, that of the coefficient of purity is of some importance, not as to what extent it is effected by the drying out, but as to how near the truth the ordinary determination comes. Two series of experiments were made, five with Vilmorin and six with Kleinwanzlebener. These beets ranged in sugar from 9 to 14 per cent., and the coefficient obtained by evaporating to dryness to determine the total solids was sometimes higher and again lower than that found by the ordinary method, but the average of the five determinations made with the Vilmorin was the same and that with the six Kleinwanzlebener samples differed by 0.2 per cent. The average obtained as ordinarily determined being higher by this small amount.



THE EFFECT OF SIZE OF BEETS ON PERCENTAGE OF SUGAR.

§ 40. The impression is that large beets will be low in sugar and that small beets will be rich in sugar. I do not recall having seen it so stated by any one writing on the subject. It is, however, claimed, and that justly, that medium sized beets are apt to be richer in sugar than larger ones, and under ordinary conditions they will be richer than very small ones. It should be remembered that such statements are only true in a general sense and do not exclude exceptions either way. Having seen so many exceptions to the statement that large beets were apt to be poor in sugar, I endeavored to determine the influence of size upon the percentage of sugar.

We sometimes find large beets in a row where the stand is regular, and the large and small beets have, to all appearances, had equal chances, with the general conditions favorable to the formation of beets rich in sugar. Again we find beets grown under conditions which we know from observation to be unfavorable to the growth of beets rich in sugar, whether they are large or small. Again, we know that beets grown from different seed, and on different plots of ground, differ in quality. I shall give examples showing this to be the case with different parts of rows, one end yielding markedly better beets than the other, without regard to size.

§ 41. In order, then, to study whether a large size has any prejudicial relation to the sugar content, I took beets of different sizes grown under the same conditions, *i. e.*, I took all of the beets growing in a certain length of row and analyzed each one separately where they were large enough to make a sample; if not, two were taken together.

This was done with a number of rows, and the results are given in the following table:

TABLE IV.—RELATION OF SIZE OF BEETS TO SUGAR CONTENT.

| <i>Number.</i> | <i>Weight of Beet in Pounds.</i> | <i>Percentage of Sugar in Beet.</i> | <i>Coefficient of Purity.</i> |
|----------------|----------------------------------|-------------------------------------|-------------------------------|
| 1.....         | 4.40                             | 13.35                               | 79.6                          |
| 2.....         | 4.00                             | 14.16                               | 73.0                          |
| 3.....         | 3.25                             | 14.96                               | 81.9                          |
| 4.....         | 2.90                             | 16.06                               | 85.1                          |
| 5.....         | 2.60                             | 14.77                               | 80.8                          |
| 6.....         | 2.40                             | 14.44                               | 76.8                          |
| 7.....         | 1.75                             | 16.96                               | 82.5                          |
| 8.....         | 1.60                             | 15.39                               | 79.7                          |
| 9.....         | 1.50                             | 15.06                               | 81.0                          |
| 10.....        | 1.50                             | 15.68                               | 83.1                          |
| 11.....        | 1.45                             | 16.44                               | 79.9                          |
| 12.....        | 1.20                             | 15.77                               | 85.8                          |
| 13.....        | 0.75                             | 14.73                               | 77.5                          |
| 14.....        | 0.62                             | 15.44                               | 81.0                          |
| 15.....        | 0.62                             | 15.58                               | 83.4                          |
| 16.....        | 0.62                             | 12.97                               | 70.3                          |
| 17.....        | 0.50                             | 14.30                               | 74.5                          |
| 18.....        | 0.40                             | 14.58                               | 78.0                          |

§ 42. This set of samples shows that beets ranging from 1.20 to 1.75 pounds, Nos. 12 to 7 inclusive, are preferable to either larger or smaller beets. It happens that we have six beets ranging from 2.4 to 4.4 pounds, showing an average of 14.62 per cent. of sugar, and six beets weighing less than a pound each, whose average sugar content is 14.60 per cent. I consider this a reasonably fair test of this point, as the samples are of the same variety and taken consecutively, and from a portion of the rows where the stand was perfect. The beets were mature and in fine condition.

§ 43. Another set of samples was taken of another variety which had grown near an irrigating ditch, and near the edge of the patch. I knew that these conditions tended to the growth of large beets of low quality. But I desired to see what the relation of size to quality was in these. This variety was not known. The seed was purchased for Lane's Imperial, but they were not Lane's Imperial, being a sugar beet of the type of the Kleinwanzlebener, and but little inferior to this variety when grown under like conditions. This variety, under fairly favorable conditions, showed an average of 13.25 per cent. sugar, against 13.97 per cent. for the Kleinwanzlebener. A sample of this variety, grown on my own plot and taken a few days before these, showed 12.59 per cent. sugar, with a coefficient of purity of 77.6.

TABLE V.—RELATION OF SIZE OF BEETS TO SUGAR CONTENT—  
(Continued).

| <i>Number.</i> | <i>Weight of<br/>Beets in Pounds.</i> | <i>Percentage of<br/>Sugar in Beets.</i> | <i>Coefficient<br/>of Purity.</i> |
|----------------|---------------------------------------|------------------------------------------|-----------------------------------|
| 1.....         | 8.62                                  | 10.59                                    | 67.5                              |
| 2.....         | 8.12                                  | 10.45                                    | 68.3                              |
| 3.....         | 6.90                                  | 9.64                                     | 62.5                              |
| 4.....         | 5.70                                  | 9.50                                     | 65.2                              |
| 5.....         | 5.16                                  | 10.45                                    | 65.9                              |
| 6.....         | 3.15                                  | 12.11                                    | 72.3                              |
| 7.....         | 2.88                                  | 10.45                                    | 67.0                              |
| 8.....         | 2.82                                  | 9.26                                     | 62.1                              |
| 9.....         | 2.71                                  | 10.21                                    | 64.7                              |
| 10.....        | 2.27                                  | 8.46                                     | 66.6                              |
| 11.....        | 2.01                                  | 9.98                                     | 66.0                              |
| 12.....        | 1.78                                  | 10.45                                    | 66.5                              |
| 13.....        | 1.55                                  | 12.35                                    | 70.1                              |
| 14.....        | 1.08                                  | 10.45                                    | 65.9                              |
| 15.....        | 0.25                                  | 11.88                                    | 69.7                              |

§ 44. This set of samples is no more decisive than the preceding. If it shows anything, it is that beets from one quarter to one and three quarter pounds will be better than larger beets; but taking the individual beets, we observe that the eight-pound beets are as good or better than the one pound sample, and that the three-pound sample is better than the one quarter pound one. The size seems less determinative under conditions of abundant moisture and favorable soil conditions than under others.



§ 45. Being altogether dissatisfied with the results of these observations, I thought to eliminate the variation in the individual beets by digging a section of a row, dividing the beets according to weight into different samples, and determining the sugar in these. Further, to decrease the chance of error by happening to get either too good or too poor a sample, I took two sections of each row, one from the east half and one from the west half, and further still, I took four varieties. The east half and west half of the patch received the same treatment, except in one particular. The distance to which all of the beets so far mentioned were thinned was from 6 to 8 inches. The results are interesting, and are given in the following table:

TABLE VI.—RELATION OF SIZE OF BEETS TO SUGAR CONTENT—  
(Continued).

| VARIETY.                             | East Half.        |                  |                          |                                           |                               |                        | West Half.        |                  |                          |                                           |                               |                        |
|--------------------------------------|-------------------|------------------|--------------------------|-------------------------------------------|-------------------------------|------------------------|-------------------|------------------|--------------------------|-------------------------------------------|-------------------------------|------------------------|
|                                      | Number of Sample. | Number of Beets. | Average Weight of Beets. | Average Distance Between Beets in Inches. | Percentage of Sugar in Beets. | Coefficient of Purity. | Number of Sample. | Number of Beets. | Average Weight of Beets. | Average Distance Between Beets in Inches. | Percentage of Sugar in Beets. | Coefficient of Purity. |
| Vilmorin Improved...                 | 1                 | 9                | 2.72                     | 7.3                                       | 13.11                         | 75.5                   | ....              | 7                | 1.51                     | 8.25                                      | 15.06                         | 81.7                   |
|                                      | 2                 | 4                | 2.49                     | .....                                     | 13.30                         | 75.0                   | ....              | 13               | 1.05                     | .....                                     | 16.15                         | 83.3                   |
|                                      | 3                 | 11               | 1.56                     | .....                                     | 13.90                         | 79.2                   | ....              | 9                | 0.43                     | .....                                     | 15.11                         | 79.5                   |
|                                      | 4                 | 6                | 1.05                     | .....                                     | 13.78                         | 78.2                   | ....              | ....             | .....                    | .....                                     | .....                         | .....                  |
|                                      | 5                 | 6                | 0.62                     | .....                                     | 13.78                         | 75.8                   | ....              | ....             | .....                    | .....                                     | .....                         | .....                  |
| White Imperial .....                 | 6                 | 4                | 3.30                     | 6.99                                      | 12.11                         | 69.3                   | ....              | 3                | 2.66                     | 6.66                                      | 13.07                         | 72.4                   |
|                                      | 7                 | 9                | 2.33                     | .....                                     | 10.40                         | 64.8                   | ....              | 6                | 1.49                     | .....                                     | 13.68                         | 75.8                   |
|                                      | 8                 | 13               | 1.46                     | .....                                     | 11.88                         | 70.9                   | ....              | 16               | 0.97                     | .....                                     | 14.73                         | 80.0                   |
|                                      | 9                 | 11               | 1.00                     | .....                                     | 11.64                         | 66.4                   | ....              | 11               | 0.58                     | .....                                     | 12.88                         | 70.9                   |
|                                      | 10                | 12               | 0.46                     | .....                                     | 12.30                         | 68.1                   | ....              | ....             | .....                    | .....                                     | .....                         | .....                  |
| White French.....                    | 11                | 4                | 3.82                     | 8.13                                      | 11.92                         | 76.8                   | ....              | 11               | 2.36                     | 9.3                                       | 13.68                         | 73.7                   |
|                                      | 12                | 6                | 2.45                     | .....                                     | 14.25                         | 84.3                   | ....              | 9                | 1.70                     | .....                                     | 13.44                         | 72.4                   |
|                                      | 13                | 4                | 1.67                     | .....                                     | 14.25                         | 86.0                   | ....              | 4                | 1.12                     | .....                                     | 14.20                         | 70.3                   |
|                                      | 14                | 4                | 1.17                     | .....                                     | 13.44                         | 72.2                   | ....              | 7                | 0.49                     | .....                                     | 14.73                         | 74.8                   |
|                                      | 15                | 13               | 0.60                     | .....                                     | 13.35                         | 71.9                   | ....              | ....             | .....                    | .....                                     | .....                         | .....                  |
| Dippe's Improved Kleinwanzlebener... | 16                | 4                | 2.22                     | 6.3                                       | 15.25                         | 76.3                   | ....              | 14               | 1.42                     | 6.48                                      | 16.63                         | 79.8                   |
|                                      | 17                | 7                | 1.66                     | ....                                      | 15.77                         | 77.1                   | ....              | 11               | 0.97                     | .....                                     | 16.37                         | 77.9                   |
|                                      | 18                | 10               | 1.09                     | .....                                     | 15.34                         | 75.0                   | ....              | 12               | 0.48                     | .....                                     | 16.58                         | 75.7                   |
|                                      | 19                | 17               | 0.48                     | .....                                     | 15.91                         | 74.7                   | ....              | ....             | .....                    | .....                                     | .....                         | .....                  |

§ 46. The beets from the west half are by far better than those from the east half, and this, too, without regard to size, so that the beets from the two halves cannot be compared with one another. The number of beets exceeding 1.5 pounds from the east half stand to those from the west half as more than 2 to 1. The length of row dug was carefully measured, and the distance apart in the row determined; for the Vilmorins it was 7.3 inches in the east, and 8.25 inches in the west half; for the White Imperial it was 6.99 in the east and 6.66 in the west half; for the White French, 8.13 inches in the east and 9.3 in the west half, and for the Dippe's Kleinwanzlebener it was 6.3 in the east and 6.48 inches in the west half. The distance between the beets is well within the generally assumed proper limit. The shortest section of row dug was 20 feet, and the length of the rows was 400 feet.

§ 47. A casual inspection of the table leaves the impression that the beets from the west end of the patch are smaller than those from the east half, and are richer in sugar than these. This is true, but I do not believe that the rest of the inference likely to be drawn, *i. e.*, that it is because of their smaller size that they are richer, is justified. I believe that this depended upon some other factor.

§ 48. It is difficult to satisfy oneself by a study of the results given in this table that there is anything shown by it more definitely than by the preceding ones. Taking each of the samples by itself, that is, comparing beets grown side by side, we find only two sets in the six where there is any decided difference in favor of the smaller beets, and these two are of the same variety, the White French, and the larger beets weigh from 3 to 7 times as much as the smaller beets. We cannot even allow this uncertain advantage to the smaller beets, in regard to coefficient of purity, for, according to the table, the difference is in favor of the larger beets. If from this table we select beets of the same size for comparison, we will find that those from the west end are the richer and better beets. The few exceptions which we find to this statement are confined to the White French variety. If we had dug the whole of the rows, and selected all of the beets weighing upwards of two pounds, we would have gotten at least two thirds of the sample from the east half of the patch, and if we had, in the same manner, collected a sample of beets weighing less than one pound, we would have gotten more than half of it from the west end, and these samples would not give us the data to judge of the relation of size to percentage of sugar. It would be, in a considerable degree at least, equivalent to comparing the large beets grown in the one half with the small beets grown in the other half, which conceals the relation between the size of the beet and its percentage of sugar.



If from the preceding table we take the average of all the samples in which the individual beets exceed two pounds, and compare it with the average of all those in which the beets weighed less than one pound, we find a difference of 1.5 per cent. sugar in favor of the small beets, which is actually a greater difference than is shown between the largest and smallest beets in any single experiment in the series. In order to make this comparison, we must take beets grown side by side, which we have endeavored to do, finding as the result of the eight experiments recorded in the last table, that beets weighing about one half pound contained, as compared with beets weighing upwards of two pounds, in one case more than 1 per cent. more sugar, in two cases more sugar by 0.67 per cent.; in one case more by 0.19 per cent., and in one case less by 0.19 per cent. Of four varieties experimented with, the maximum difference shown by three of them in favor of the small beets is 0.67 per cent., while the fourth shows a difference of a little more than 1 per cent.

§ 49. The second table given under this subject, being the results obtained from an experiment with beets of very large size, and grown at or near the edge of the patch, with a constant and abundant water supply, suggested an explanation for the general impression that large beets are poor beets. Excessively large sugar beets, 8 to 10 pounds or upwards, are unusual. Such beets are grown under such conditions as above given, at the edge of a patch with abundant water and plant food, or where they stand alone. I have analyzed Kleinwanzlebener beets grown in this manner that were very poor, showing less than half as much sugar as the average of the patch. In other words, very large size and low quality are associated with an almost unlimited feeding ground and abundance of water. There was a single row of beets on the Farm which had practically been grown under these conditions, except that the beets were thick in the row. There were three varieties: Vilmorin, White French and White Imperial. Samples of each of the varieties were taken by digging a piece of the row and sorting the beets into different lots, according to size.

TABLE VII.—EFFECTS OF EXCESSIVE FEEDING GROUND ON QUALITY OF BEETS.

| VARIETY.            | Number of Beets. | Average Weight of Beets in Pounds. | Percentage of Sugar in Beets. | Coefficient of Purity. | Percentage of Sugar in Beets Grown in Patch. Rows 18 inches, Beets 8 inches. | Coefficient of Purity. |
|---------------------|------------------|------------------------------------|-------------------------------|------------------------|------------------------------------------------------------------------------|------------------------|
| Vilmorin.....       | 6                | 2.02                               | 12.78                         | 75.5                   | .....                                                                        | ....                   |
|                     | 9                | 0.50                               | 14.30                         | 80.0                   | 13.97                                                                        | 79.2                   |
| White French.....   | 9                | 1.95                               | 11.50                         | 73.0                   | .....                                                                        | ....                   |
|                     | 12               | 0.33                               | 11.82                         | 72.2                   | 13.16                                                                        | 80.3                   |
| White Imperial..... | 10               | 1.56                               | 10.31                         | 68.5                   | .....                                                                        | ....                   |
|                     | 3                | 0.84                               | 11.50                         | 74.2                   | .....                                                                        | ....                   |
|                     | 18               | 0.17                               | 10.59                         | 70.7                   | 11.88                                                                        | 70.9                   |

§ 50. This exhibits the effect of growing free, which would probably have been more pronounced had the beets not been so crowded in the row. The Vilmorins averaged one beet to each 3.4 inches, the White French one to each 3.5 inches, and the White Imperial one to each 2.4 inches. This made the beets so thick that they pressed one another outward from the row, and modified the effect of the row being single and with an excess of room laterally. In the case of the Vilmorin there is a decided superiority shown by the small beets in both percentage of sugar and coefficient of purity, 1.5 per cent. in sugar and 4.5 in purity. The other two are so close that it is not decisive. The average of the Vilmorin is so close to the value found for the sample taken from the patch that it is not clear that the difference is due to the amount of space at the disposal of the beets. In the other two, however, there is a difference of one and one and a half per cent., respectively, in favor of the beets grown in the patch. The two soils in which these samples were grown are equally good, so far as one can judge.

§ 51. My conclusion is that in the case of beets growing side by side, those ranging in weight from one to two pounds are richer in sugar, and of higher purity, than either the larger or smaller, and of the latter that there is a slight difference in percentage of sugar in favor of the smaller beets. But the difference in purity is slightly in favor of the larger beets, and in neither case is the difference great or constant. But large beets, grown under conditions differing from those under which the smaller beets have been grown, cannot be compared with the smaller ones. I also take it, as indicated by the values obtained from the samples from our



single row, that two great a width between the rows tends to have the same effect as permitting the beets to grow singly.

#### EFFECTS OF OVER IRRIGATION.

§ 52. The difference in the size of the beets, it being smaller, and their sugar content, it being higher, in the west end of one of our patches than in the east end, seemed difficult to explain, as the patch was only 400 feet long, and the soil seems equally good throughout. Our field notes, however, call attention to the fact that the west end is hard and the foliage is yellow, as though water had stood there, puddled the ground and produced the yellowness of the leaves. As this was the only perceptible difference in the conditions at the east and west ends, there remained nothing else to which to attribute the difference in the quality of the beets. There was another patch on the Farm in which this had happened, and we collected samples from this patch also and analyzed them, together with samples taken from the same patch, but which had not suffered from this cause. It appears from the table on page 27 that the average of all the samples taken from the west end exceeds by 0.71 per cent. that of all the samples from the east end. An examination of the table in detail shows how constantly the samples from the west end were better than those from the east end, though the average difference is only 0.71 per cent. The samples obtained from the other patch, consisting of eight beets each, the one yellow from the effects of too much water, the other taken a few feet away but green and healthy looking. The beets of both samples were small. In the green sample they averaged 0.62 pound. This sample showed 13.78 per cent. sugar and 79.1 purity. In the over irrigated sample the average weight was 0.66 pound. This sample showed the presence of 17.20 per cent. sugar and 89.1 coefficient of purity. It was at this time so late in the season that we could not follow this subject, and postponed further observations until the next season, 1899. I was, in a certain sense, thwarted in this part of my work; but in another sense I was not. In making an experiment with irrigating water I had an opportunity to over irrigate my beet plot and subject it to a treatment reproducing the conditions of these over-irrigated patches.

§ 53. My plot did not need water, but wishing to make observations on the changes in the amount of solids, etc., which go into solution and pass into the ground water, I obtained, through the kindness of Capt. Hawley, our Water Commissioner, enough water to thoroughly soak the ground, raising the water plane quite to the surface. This irrigation was made August 31 to September 2 inclusive. The ground was not disturbed, but allowed to settle and become hard. The beets were left to themselves until dug. The ground did become hard, and the beets showed the effect of

over irrigation by turning yellow in places. The average for this plot in 1898 was 13.65, and the average for all samples analyzed at the Station that season was 13.62 per cent. The average for this crop, 1899, which was over-irrigated in early September, was 14.69 per cent. I have no way of judging whether I diminished the yield by treating the crop as I did, but it was the largest yield that I have yet gotten off of this ground. The size of the beets in the over-irrigated patches of the season of '98 give contradictory indications. It seems probable that the yield would be diminished, but it certainly was not materially affected in any of the observed cases.

§ 54. These facts seem to contradict the generally accepted view that a rainfall in the latter part of September or early October may effect the beets unfavorably. I recorded, in 1897, the effect of a rainfall of about .75 of an inch as depressing the sugar content to an extent which the beets did not overcome for three weeks. I think that the explanation is not difficult. A moderate rainfall may do one of two things, according to the condition of the crop at the time of its fall. If the crop is growing slowly, but has not begun its rest period, the rain may very materially increase its rate of growth, and an increase in weight of crop may take place more rapidly than the formation of sugar. This would produce a depression in the percentage of sugar present, but the percentage might be subsequently regained or exceeded. If the crop had already begun its resting period, had begun to ripen, the rain might, as it often does, produce a new growth, that is, a second growth, in which new leaves are produced, a fact familiar to every one. In this case there is a real diminution of the sugar present, and not only an apparent one due to a disproportionately large increase in the weight of the crop. In the over irrigation we have neither of these cases. On the contrary, the effort was to keep the beets growing steadily, but to puddle the soil tightly about them at a period not too much in advance of their normal time of maturing and then to leave them. I do not believe that the same results would follow in all soils, nor if the excessive irrigation should be applied at a time when it would cause the crop to take on a new growth, but there does seem to be enough promise in it to justify a sufficiently extensive series of experiments to determine the exact conditions of soil and time when it will produce advantageous results, as there is no doubt but that such conditions exist.

#### BEET ASH AND ITS COMPOSITION.

§ 55. In 1897 I endeavored to determine the ash at different periods in the development of the beet, and the effect of the different soil conditions upon the composition of the ash. There was a series of analyses of beet ashes, seventeen in number, made during the



season. Thirteen of these ashes represented varieties of sugar beets, mostly the Kleinwanzlebener variety. The reason that my work was confined to this one variety was that the results obtained showed so little variation that the information to be obtained did not promise to be commensurate with the labor involved. Our conclusion from that series of analyses was, that probably owing to the richness of the soil in the elements of plant food necessary for the beet, the alkali present had exerted but little or no influence on the composition of the ash. The ash in that series which showed the largest amount of soda was one prepared from beets grown on a Farm plot free from alkali, or as much so as any of our soils. The only thing which we observed in the analyses which might be taken as indicating anything characteristic of the soil, was the tendency shown toward a high chlorin percentage. We have not endeavored to study this subject in such detail in the subsequent years, but have reduced the number of samples, enlarging them at the same time, so as to make them thoroughly representative. As we had selected the Kleinwanzlebener variety in 1897, we selected it also in 1898. The samples were not only of the same variety, but were grown on the same ground, so the ashes ought to give us a measure of the influence of the manure applied, and the effect of the cultivation if the composition of the ash is materially affected by these factors. Our conclusion in 1897 in regard to this point, was that the composition of beet ashes was relatively constant, within comparatively narrow limits. The following analyses corroborate this view, though they are not given for this purpose:

TABLE VIII.—GIVING COMPOSITION OF ASHES OF BEETS GROWN WITH AND WITHOUT MANURE.

|                                  | Kleinwanzlebener.<br>Chemical Plot<br>Manured. 1898. | Kleinwanzlebener.<br>Chemical Plot.<br>Not Manured. 1898. | Kleinwanzlebener.<br>Chemical Plot.<br>Not Manured. 1897. | Vilmorin Improved.<br>Farm Plot. 1898.<br>Not Manured. | Vilmorin.<br>Farm Plot. 1897.<br>Not Manured. | Vilmorin.<br>Chemical Plot. 1899.<br>Not Manured. | Zehringen.<br>Chemical Plot. 1899.<br>Not Manured. |
|----------------------------------|------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------|--------------------------------------------------------|-----------------------------------------------|---------------------------------------------------|----------------------------------------------------|
| Dry Matter in Beets.....         | 19.770                                               | 20.822                                                    | 18.090                                                    | 23.704                                                 | 17.500                                        | 23.493                                            | 24.423                                             |
| Ash in Dry Matter .....          | 5.650                                                | 5.433                                                     | 6.491                                                     | 5.476                                                  | 5.469                                         | 4.000                                             | 4.500                                              |
| Insoluble Ash.....               | 1.075                                                | 0.921                                                     | 1.389                                                     | 0.850                                                  | 1.311                                         | 1.350                                             | 1.150                                              |
| Soluble Ash.....                 | 4.575                                                | 4.512                                                     | 5.102                                                     | 4.626                                                  | 4.158                                         | 2.650                                             | 3.350                                              |
| Ash in Fresh Sample.....         | 1.117                                                | 1.131                                                     | 1.174                                                     | 1.298                                                  | 0.957                                         | 0.940                                             | 1.099                                              |
| Carbon .....                     | Trace.                                               | Trace.                                                    | Trace.                                                    | Trace.                                                 | Trace.                                        | Trace.                                            | Trace.                                             |
| Sand .....                       | 1.440                                                | 1.079                                                     | 1.188                                                     | 1.125                                                  | 0.931                                         | 2.613                                             | 2.139                                              |
| Silica.....                      | 0.946                                                | 0.887                                                     | 1.102                                                     | 0.652                                                  | 1.264                                         | 1.373                                             | 1.234                                              |
| Sulphuric Acid.....              | 2.760                                                | 3.062                                                     | 3.476                                                     | 3.364                                                  | 2.878                                         | 3.747                                             | 3.913                                              |
| Phosphoric Acid.....             | 9.984                                                | 8.434                                                     | 8.668                                                     | 6.923                                                  | 6.088                                         | 8.613                                             | 9.109                                              |
| Carbonic Acid .....              | 18.106                                               | 17.092                                                    | 15.690                                                    | 22.300                                                 | 19.177                                        | 16.890                                            | 15.294                                             |
| Chlorin .....                    | 10.752                                               | 11.857                                                    | 12.599                                                    | 6.966                                                  | 10.887                                        | 5.699                                             | 9.464                                              |
| Potassic Oxid.....               | 40.061                                               | 37.923                                                    | 42.976                                                    | 38.322                                                 | 40.065                                        | 40.525                                            | 38.572                                             |
| Sodic Oxid.....                  | 8.699                                                | 12.184                                                    | 8.811                                                     | 12.736                                                 | 11.161                                        | 5.878                                             | 9.219                                              |
| Calcic Oxid.....                 | 2.549                                                | 2.612                                                     | 1.951                                                     | 2.356                                                  | 3.409                                         | 4.106                                             | 2.900                                              |
| Magnesian Oxid.....              | 5.745                                                | 5.366                                                     | 5.573                                                     | 5.156                                                  | 5.264                                         | 7.226                                             | 7.242                                              |
| Ferric Oxid.....                 | 0.273                                                | 0.306                                                     | 0.146                                                     | 0.238                                                  | 0.414                                         | 0.396                                             | 0.707                                              |
| Aluminic Oxid.....               | 0.087                                                | 0.303                                                     | 0.538                                                     | 0.100                                                  | 0.774                                         | 0.184                                             | 0.193                                              |
| Manganic Oxid.....               | 0.195                                                | 0.331                                                     | 0.195                                                     | 0.152                                                  | 0.186                                         | 0.310                                             | 0.204                                              |
| Loss on Ignition.....            | 1.519                                                | 1.626                                                     | .....                                                     | 1.532                                                  | .....                                         | 3.454                                             | 2.308                                              |
| Sum .....                        | 103.109                                              | 103.062                                                   | 102.912                                                   | 101.922                                                | 102.498                                       | 101.014                                           | 102.498                                            |
| Oxygen Equivalent to Chlorin.... | 2.423                                                | 2.672                                                     | 2.839                                                     | 1.570                                                  | 2.441                                         | 1.284                                             | 2.132                                              |
| Total .....                      | 100.686                                              | 100.390                                                   | 100.073                                                   | 100.352                                                | 100.057                                       | 99.730                                            | 100.366                                            |

§ 56. This table shows the composition of beet ashes obtained from beets grown on three different soils and under different conditions, both of season and cultivation. The differences in the percentage of dry matter in these samples are, as I have already suggested, to be attributed to seasonal influences rather than to differences due to variety and cultivation. But whether the other differences, such as is observed, for example, in the percentage of the phosphoric acid, is to be attributed to the differences in the soils, season or cultivation, appears open to doubt, though the



higher percentage of this acid in the ash of beets grown on the manured ground indicates that the cultivation has an influence upon the amount of this component of the ash, tending to increase it. On page 48, Bulletin 46, is given an analysis of the ash of a sample of Kleinwanzlebener beets grown in New Mexico, in which we have less than 4 per cent. (3.336 per cent.) of phosphoric acid, showing that ash from the same variety may have a varying composition, due to differences of soil, and it may be that the lower phosphoric acid in the Vilmorin ashes, given in the table, is due to this, and not to variety, for these samples were grown on different plots in 1897 and 1898, while the Kleinwanzlebener samples were grown on the same plot, one half of which, however, had received a dressing of manure. The percentage of chlorin shows the greatest change as a result of the cultivation and continued cropping. In 1897 the ash of the Kleinwanzlebener beets contained 12.599 per cent. of chlorin; in 1898, grown on the portion which had not been manured, the ash contained 11.857 per cent., and the ash of the beets grown on the manured portion contained 10.752 per cent. The highest percentage of chlorin found in the ashes of the Zehringen variety, in 1899, was 9.464 per cent., while the Kleinwanzlebeners showed only 5.699 per cent. chlorin present in the ash. These last two samples were grown on soil which had not at any time received a dressing of manure. These percentages indicate a decrease in the amount of chlorin taken up by the beets, as the soil conditions are improved. There has been, at the same time, an improvement in the quality of the beets. In 1897 the Kleinwanzlebener variety showed 11.76 per cent. sugar, 76.0 purity; in 1898, 13.97 per cent. sugar, 84.6 purity; in 1899, 15.34 per cent. sugar, 80.8 purity. For two years, 1897 and 1898, the percentages of sulphuric acid, phosphoric acid, lime and magnesia remained almost the same. In 1899, however, the percentages of lime and magnesia increased by about 1 per cent. in each case. Previous to 1899, the highest percentage found for the magnesia was 5.74 per cent., but in 1899 it reached 7.25 per cent., an increase of 1.5 per cent. In the case of the lime, the highest percentage found, in 1897 and 1898, was 2.826 per cent.; in 1899, 4.106 per cent.; also an increase of nearly 1.5 per cent. These samples were grown on the same plots, and were of the same variety of beets. The changes observed are toward a closer agreement with other analyses than heretofore. These percentages do not establish permanent changes, but do show the tendency which the continued cropping and cultivation of this soil has to modify its effects upon the mineral matters taken up by the plants. The tables giving the percentage of sugar and the coefficient of purity for these crops show a decided improvement in the three years covered by the experiments, and the analyses of the ashes show the tendency which manuring,

cultivation and continued cropping to the same crop, has to ameliorate the effects of unfavorable soil conditions.

§ 57. Reference was made to the question as whether the manure added to the soil, acted, in this case, as a fertilizer or as a mechanical agent, simply improving the physical condition of the soil. The composition of the ash shows that its action is not merely physical but is well marked chemically, in that the percentage of chlorin is lowered and that of phosphoric acid is increased.

§ 58. Reference to the Tables Nos. I. and II., showing the percentage of sugar, etc., for the years 1898 and 1899, will show that the effect of the manure upon the sugar content and coefficient of purity was not marked until the end of the season, or the period of ripening. This was especially true in 1898; the difference in favor of the not manured plots being greater in 1899 than in 1898. It should, however, be borne in mind that all of the beets in '99 are remarkably high in sugar, and quite up to the average in purity, and while the beets grown on the plots having received no manure were better than those grown on plots which had received manure, it is not to be inferred that the latter were poor beets in regard to either sugar content or purity, for the averages for the two varieties grown on the manured plots in 1899 were 15.06 per cent. sugar, 81.7 purity, and 14.15 per cent. sugar, 77.7 purity, while those grown without manure showed 15.34 per cent. sugar, 80.8 purity, and 16.24 per cent. sugar and 84.5 purity.

The effects of the straw were probably almost wholly mechanical, and this effect was very evident. The effect of the sheep manure was evident in the improvement of the physical condition of the soil, in the germination of the seed, the more vigorous growth of the crop, the shape of the beets, the sugar content of the beets, the coefficient of purity, and in its effects upon the composition of the ash.

§ 59. The effects of the manure upon the vigor of the growth, the percentage of sugar and the coefficient of purity were quite as marked in the second as in the first crop grown on the soil after the application of the manure. The manure being more thoroughly incorporated with the soil the second year, did not produce as marked effects upon the shape of the beets as it did the first year.

#### COMPOSITION OF THE MANURE APPLIED.

§ 60. It has already been stated that the amount of manure applied was at the rate of sixty-four tons to the acre, also that it was applied broadcast in February and plowed under in May. At the time of the application of the manure, my opinion was that this soil was so abundantly rich in plant food that the only effect of the manure would be mechanical. The results observed show that



its effects were varied, and it apparently produced important chemical changes in the soil, because of its fertilizing ingredients.

§ 61. This manure contained, at the time of its application, 45.14 per cent. of dry matter, or 28.89 tons of dry matter was applied per acre.

§ 62. The ammonia in the fresh manure was equal to 0.926 per cent. of nitrogen. This determination was made by distillation with magnesian oxide, to learn how much of the total nitrogen existed in the manure in the form of ammonia and ammonia salts; also to learn how great a loss might be suffered by the volatilization of this compound under the influence of our winds and sunshine. The loss in our particular case was probably large, as the weather remained clear for some time after the application of the manure, and dried it out until it became very dry. The percentage of the total nitrogen, which was set free as ammonia by the magnesian oxide, was 47.22 per cent., and the amount expelled by drying the manure to a constant weight in a water oven was 60.73 per cent. of the total. I do not know the power of this soil to absorb the ammonia which was readily formed in the manure, but it is evident that the danger of loss was, under the conditions given, greater than one would expect. Had rain fallen immediately after the application, the loss would have been much smaller than it probably was.

§ 63. The total nitrogen present in the manure was 1.940 per cent., or the nitrogen applied was at the rate of 2,483.2 pounds per acre; or if we allow a loss of one fourth of the nitrogen, due to volatilization and failure of the soil to absorb the ammonia, there would remain 1,861.6 pounds to the acre. The phosphoric acid in the fresh manure was 0.654 per cent., or an application of 837.1 pounds, equivalent to 1,573.4 pounds of calcic hydric phosphate per acre.

§ 64. The potassic oxide equaled 2.427 per cent of the fresh manure, or a dressing of 4,077.36 pounds of potassic oxide to the acre, equivalent to 8,543.11 pounds of potassic sulphate. We have the application of 2,483.2 pounds of nitrogen, 1,573.4 pounds of calcic hydric phosphate and 8,543.1 pounds of potassic sulphate, or their equivalent, together with nearly 25 tons of organic matter, producing the effects recorded in the preceding pages.

§ 65. The most salient question suggested by a comparison of the composition of the manure applied and the results produced, is in regard to the phosphoric acid and potassic oxide, the former being materially increased in the ash of the beets, while the latter, on the contrary, is not effected, or is possibly decreased. The amount of potassic oxide applied is greatly in excess of the phosphoric acid, and the ratio of the potassic salts to the phosphates in the manure is

greater than the ratio of potash to phosphoric acid in the ash. The effect of the manure is probably to be found in the specific action of the nitrogen and the organic matter. I think that the analyses of the soil will tend to establish this view.

§ 66. The nitric acid in the ground water in 1898 is more variable and much higher than it was in 1897, but on the other hand, the water level stood somewhat higher in 1897 than it did in 1898, the difference being about one foot. I think that the smaller quantity of water applied to the surface in 1898, either as irrigation water or as rain, tending perhaps to yield a more concentrated percolate, will not account for the greatly increased amount of nitric acid in the ground water, but that it is to be explained chiefly by the oxidation of the nitrogen added to the soil in the manure.

§ 67. The total solids in the ground water in 1898 were higher, as a rule, than in 1897, but whether they were as much higher as the supply of water was less, I cannot say. I know that it does not hold good that the total solids in the water are larger in amount as the water is lower. The greater the depth of soil the water has to travel through, the less likely we are to find excessively large amounts of the total solids in the water.

§ 68. In 1899 we had a larger amount of water as sub-irrigation water, and it may be doubted whether the total solids contained in the ground water should be used as a criterion of the effect of the manure, *i. e.*, as a measure of the chemical changes induced by the manure. I regret that the relation here is so obscure and involved that it lessens the value of the results obtained, but our observations show that the total solids fell again in 1899 to a lower point than they showed in 1897.

Irrigation or heavy rains which fill the soil with water, raise the water level, and cause an increase in the chlorin contained in the ground water. The manure applied seemed to make the increase more pronounced and of greater duration.

The analyses of the ground water in 1898 do not show a sufficiently marked difference to justify any further inferences than those based upon the nitric acid and chlorin. We shall discuss this part of our work more fully in the succeeding part of our study.

§ 69. The effects upon the crop indicate that the manure applied produced not only mechanical effects upon our soil, but also chemical effects, both tending to improve its condition and eliminate the effect of the alkali in increasing the percentage of ash. But it is not clear what relation exists between the composition of the manure and the general effects produced. The observations made upon the effects of the straw, and the increased amount of nitric acid in the water (it is understood that this nitric acid is present in



the form of nitrates), incline me to the view that the organic matter, including the nitrogen, played an important part in our particular case.

#### SOAKING EXPERIMENTS.

§ 70. It is a universally acknowledged fact that the maturing of the beet is accompanied by an increase in the coefficient of purity; that is, that the sugar in the juice of ripe beets constitutes a larger percentage of the total solids than it does in the juice of green beets. The percentage of sugar in the ripe beet is also higher than in the same beet when it is green. The increase in the ratio of the sugar to the solids not sugar, might be due to an increase in the amount of sugar, without any change in the amount of the other solids, in which case there would be an increase in the weight of the beets, corresponding to the increase in the amount of sugar and of the dry matter in the beet. There is, however, a disappearance of solids not sugar at this period, which indicates that the percentage of total solids in the beet is not maintained at an approximately constant figure by a proportional increase of crop and sugar content, but a proportional decrease of the one and increase of the other.

§ 71. The following experiments were made in an endeavor to obtain more definite information on this subject, *i. e.*, whether this change of material into sugar may continue after the beet has been pulled; for if we can prove an increase in the amount of sugar, before and after soaking, the probability of such a change in the living beet is strengthened. In 1897 we found that there was a period during which sugar was rapidly formed, but that sugar was present early in the history of the crop, and that there was a slow increase, after the growing season for the crop had passed, even extending up to the early part of January, the beets having been left in the ground and covered with straw.

In 1898 a different experiment was performed. Four varieties of beets were chosen, Vilmorin Improved, White Imperial, White French and Kleinwanzlebener. Sixty-eight beets of the first and sixty of each of the last three varieties were taken, and after washing were paired, according to size, and one of each pair taken for immediate analysis, while the other was taken for soaking. The halves of the samples obtained in this manner varied but little from one another, the maximum difference being six pounds on a sample weighing 132 pounds. One half was analyzed immediately, the other half was packed in galvanized iron tubs, with fine sand, in such manner that the beets did not touch one another; water was added till the tubs were full, and pieces of ice were placed on top of them. The samples were soaked in this manner for seven days. The temperature of the water in the interior of the sand ranged from 41° to 48° F. throughout this time. The results were as follows:

TABLE IX.—SHOWING THE EFFECTS OF SOAKING BEETS ON THE SUGAR CONTENT.

| Year.        | Variety.               | Before Soaking.            |                            |                  |         | After Soaking.   |                        |
|--------------|------------------------|----------------------------|----------------------------|------------------|---------|------------------|------------------------|
|              |                        | Number of Beets in Sample. | Weight of Beets in Pounds. | Pounds of Sugar. | Purity. | Pounds of Sugar. | Coefficient of Purity. |
| 1898.....    | Vilmorin Improved..... | 34                         | 65.00                      | 8.2435           | 76.5    | 9.7657           | 78.8                   |
|              | White Imperial.....    | 30                         | 59.50                      | 6.8960           | 74.0    | 7.0420           | 74.4                   |
|              | White French.....      | 30                         | 67.40                      | 8.8698           | 80.3    | 8.8797           | 86.1                   |
|              | Kleinwanzlebener.....  | 30                         | 24.70                      | 3.3789           | 77.0    | 3.5644           | 83.5                   |
| 1899.....    | Zehringen.....         | 30                         | 35.12                      | 5.2020           | 78.7    | 5.6451           | 84.4                   |
|              | Zehringen.....         | 15                         | 18.43                      | 2.5913           | 77.2    | 2.7628           | 83.8                   |
|              | Vilmorin.....          | 30                         | 42.20                      | 6.6549           | 82.0    | 6.8959           | 82.7                   |
|              | Vilmorin.....          | 15                         | 19.25                      | 3.0560           | 84.2    | 3.1086           | 82.5                   |
| Average..... |                        |                            |                            | 5.6115           | 78.7    | 5.9580           | 82.0                   |

§ 72. The samples taken were large enough to eliminate the errors in sampling, any effects of size of beets, and also any effects which might be attributed to variety. The same experiment was repeated twice in 1899, using two varieties. The series of experiments is wholly consistent in showing an increase in the amount of sugar after the seven days' soaking. I regret that I have not tried this experiment with beets at different periods of their growth. The experiments recorded were all made with mature beets, and the formation of sugar was going on slowly and would probably have proceeded slowly if the beets had remained in the ground with their full growth of leaves intact.

§ 73. The effect upon the coefficient of purity is quite as marked as upon the amount of sugar present. In one case, it is true, the coefficient of purity appears to have been lowered; this may really be the case, but I am inclined to consider it an accident, especially as the seven other experiments agree in showing an increase in the coefficient, while this one alone shows a decrease.

THE REDUCING POWER OF BEET CHIPS.

§ 74. Thinking that some light might be obtained on the preceding subject by determining the reducing power, shown by the beet pulp after the extraction of the sugars, reacting with alpha naphtol, by means of 80 per cent. alcohol, a series of experiments was made, in which the ground dried beets were extracted with



boiling 80 per cent. alcohol so long as the solution continued to react with alpha naphthol. I will observe, in passing, that this alcoholic extract yielded, after the alcohol had been distilled off, furfural, upon distillation with hydrochloric acid of 1.06 sp. gr. The residue thus freed from sugar was boiled for thirty minutes in a flask provided with a reflux condenser, with 1.25 per cent. hydrochloric acid solution. The solution was made to volum, and its reducing power determined. No furfural could be detected as escaping from the condenser. The results were as follows :

|                             |           |                           |
|-----------------------------|-----------|---------------------------|
| Kleinwanzlebener.....       | 9- 2-97—  | 2.535 per cent. pentoses. |
| Kleinwanzlebener.....       | 9-22-97—  | 3.415 per cent. pentoses. |
| Kleinwanzlebener.....       | 10-13-97— | 2.624 per cent. pentoses. |
| Vilmorin .....              | 10-13-97— | 3.445 per cent. pentoses. |
| Yellow Globe.....           | 10-29-97— | 2.673 per cent. pentoses. |
| Lane's Imperial.....        | 10-29-97— | 2.729 per cent. pentoses. |
| Zehringen.....              | 11-10-99— | 5.897 per cent. pentoses. |
| Vilmorin .....              | 11-10-99— | 5.615 per cent. pentoses. |
| Zehringen—after soaking.... | 11-10-99— | 5.770 per cent. pentoses. |
| Vilmorin—after soaking..... | 11-10-99— | 5.065 per cent. pentoses. |

The total furfural which the samples were capable of yielding was not determined.

§ 75. The two fodder beets, the Yellow Globe and the Lane's Imperial, were included to see whether they contained more or less of these pentose bodies than the sugar beets. In the Zehringen and Vilmorin samples of 1899, we observe that the reducing power of the extracted pulp is high. The sugar content is also high, but the table does not show a decrease in these substances as the beet matures; at best, it is not conclusive, because the series is not extended enough. But three out of four show a lower percentage for pentoses, accompanying a lower sugar percentage, and four out of five show a higher percentage, accompanying the higher sugar percentage. The two soaked samples agree in showing a decrease in the pentoses present, which may be due to transformation of these bodies into others. It seems probable that not only the monosaccharids, such as glucose, may suffer change into polysaccharids, but that the pentoses may also be involved in similar changes.

#### THE SUGARS IN BEET LEAVES.

§ 76. I have tried four methods in my efforts to prove the presence of sucrose in the leaves and to determine its quantity.

The first one tried was the investigation of the expressed juice of the leaves. This was very unsatisfactory, and led to no conclusion except that there is in the juice of the leaves one or more bodies which yield upon hydrolysis with hydrochloric acid bodies which reduce Fehling's solution, but I did not succeed in establishing the presence of sucrose by this method.

§ 77. The expressed juice of the leaves was subjected to fermentation and subsequent distillation. Two thousand seven hundred and forty-nine grams of juice, expressed from fresh leaves, stems and blades being used, received a quantity of compressed yeast and was allowed to stand 36 hours at a temperature of from 26° to 31° C., after which it was subjected to distillation. A blank test was made as a control. The results showed the probability of fermentable sugars in very small quantities in the juice of the leaves.

§ 78. A larger quantity, 30 pounds, of stems of leaves were gathered October 20, 1899, when the deposition of sugar was supposed to be active, dried quickly, ground, and subsequently extracted with 80 per cent. alcohol. The alcohol was distilled off and the extract concentrated, a little ammonia being added from time to time. The fluid extract was treated repeatedly with ether to remove the chlorophyll, etc.; an aliquot part of it was taken and treated with lead acetate, the sugars inverted by hydrochloric acid, determined by Fehling's solution and calculated as sucrose. The total sugars found corresponded to 0.28 per cent. calculated on the green stems. The inversion was quite difficult to effect, much more so than the inversion of pure solutions of cane sugar.

§ 79. The fourth method followed was that of Brown and Morris, *i. e.*, extraction with ether, and solution of sugars in alcohol; treatment with lead acetate, removal of lead; determination of glucose by means of Fehling's solution; inversion of maltose by means of invertin, and inversion of all of the invertible sugars by hydrochloric acid.

§ 80. A sample of leaves, Kleinwanzlebener variety, gathered September 2, 9 a. m., when the beets were growing vigorously, gave the following results:

|         |       |           |
|---------|-------|-----------|
| Glucose | 0.156 | per cent. |
| Maltose | 0.030 | per cent. |
| Sucrose | 0.000 | per cent. |
| <hr/>   |       |           |
| Total   | 0.186 | per cent. |

Kleinwanzlebener, leaves gathered September 22, 9 a. m.:

|         |       |           |
|---------|-------|-----------|
| Glucose | 0.801 | per cent. |
| Maltose | 0.023 | per cent. |
| Sucrose | 0.064 | per cent. |
| <hr/>   |       |           |
| Total   | 0.888 | per cent. |



Kleinwanzlebener, leaves gathered October 13, 10 a. m.:

|         |       |           |
|---------|-------|-----------|
| Glucose | 0.398 | per cent. |
| Maltose | 0.394 | per cent. |
| Sucrose | Lost  | per cent. |
| <hr/>   |       |           |
| Total   | 0.792 | per cent. |

Vilmorin, leaves gathered October 13, 10 a. m.:

|         |       |           |
|---------|-------|-----------|
| Glucose | 0.398 | per cent. |
| Maltose | 0.186 | per cent. |
| Sucrose | 0.000 | per cent. |
| <hr/>   |       |           |
| Total   | 0.436 | per cent. |

These results agree in showing the presence of glucose and maltose, the latter being present in smaller quantity than the glucose, while cane sugar is present in subordinate quantities or absent.

As experiments show that the alcoholic extract of beet leaves yields furfurol when distilled with hydrochloric acid, indicating the presence of pentoses in this extract, which are susceptible of hydrolysis, it cannot be considered as rigorously proven that there is any cane sugar present, though the probability of its presence seems quite strong. But it is much less than has been found in the leaves of other plants which do not store sugar as a supply for the future use of the plant.

## SUMMARY.

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§ 81. The effect of the alkali is noticeable, but to a less extent than in 1897, and the area in which its effects appear are more restricted.

The application of straw, as well as of manure, improved the condition of the ground and perceptibly mitigated the effects of the alkali.

The application of manure improved the stand of beets, but did not prevent a failure to germinate in some spots.

The amount of water received by the crop of 1898, rain and irrigation water together, was about eight inches.

The water plane varied from three to six feet below the surface in different portions of the patch at various times during the season.

The force of capillarity caused water to rise 45 inches as a maximum, the surface of the soil being protected from wind and sun.

The plot receives subirrigation, though there is a drain and an open ditch, supposed to intercept this water.

The cultivation in 1897 differed in one respect from that given in 1898 and 1899. In 1897 the crop received two irrigations and more cultivations than in the latter years. The soil was kept more mellow. In 1899 it was purposely firmed about the beets in September, and no effort was made to mellow it after this. The percentage of sugar in 1898 and 1899 was higher than in 1897. This was in part caused by the condition of the soil produced in 1899 by intentional over-irrigation.

The effects of the manure upon the crop was to produce ill shaped, rooty beets, also to slightly lower the percentage of sugar and the coefficient of purity. Its effect on the shape of the beets was far more serious than that on the percentage of sugar and coefficient of purity.

The conclusion reached in 1897, relative to the effect of the alkalized condition of the soil upon the percentage of sugar in the



crop, is corroborated by the observations of the years 1898 and 1899, *i. e.*, that the alkali *per se* is not injurious in such quantities as it is present in any part of our plot.

The effect of the manure upon the shape of the beets was noticeable the second season after its application, but it was less marked than it was the first season. But its effect upon the percentage of sugar and the coefficient of purity was almost as marked the second year after its application as it was the first year. The peculiar soil conditions are in part the cause of this, for they retard the rotting and complete incorporation of the manure with the soil.

The marked increase in the percentage of sugar at the period of ripening, observed in 1897, was not observed in the years 1898 and 1899. The difference in the manner of maturing is attributed to the difference in the seasons. It is possible, though not probable, that such increase had already taken place before we took our first samples, September 27. The beets did not show any signs of having ripened at this time.

The beets from the Farm plots and our alkali ground showed no difference in this respect, corroborating the observation of 1897, that the alkali was without influence on the maturing of the beet.

Cut straw was applied to one section in order to compare its effects with those of the manure, as a measure of the extent to which the manure might act as a mechanical agent. It benefited the soil greatly, its mechanical effect being nearly as great as that of the manure, but the effects of the manure were in other respects much greater.

The percentage of dry matter in the beets of the years 1898 and 1899 was higher than in 1897, due, probably, to seasonal differences. The average difference for beets from my plot was 4.9 per cent. in 1898 and 3.8 per cent. in 1899.

The average percentage of sugar in the crop for 1898 was, after making allowance for some drying out of the samples, 13.62 per cent. The average of the crop grown on alkali soil was 13.65 per cent.

Medium sized beets are apt to be better than either large or small beets, but the size is less determinative of the quality of the beets than the conditions under which they grow. Beets weighing two pounds and upwards are quite as rich as those weighing less than one pound, if they have been grown under the same conditions.

The effect of excessive free space was studied on a row planted singly, with unoccupied ground for several feet on either side. The beets were very close to one another in the row. The average percentage of sugar was lower than shown by the same varieties grown in rows twenty inches apart.

Over irrigation applied at the proper time, produces, in some soils, an increase in the percentage of sugar, without materially, if at all, decreasing the crop.

The continued cropping and cultivation of our plot has slightly decreased the percentage of ash in the beet and changed its composition, particularly lowering the percentage of chlorin.

If fresh beets be soaked for seven days in water cooled by ice, an actual increase of sugar takes place, indicating the formation of sugar in the beet root.

The substances in beet chips hydrolized by dilute hydrochloric acid, are, as a rule, higher in beets rich in sugar than in stock beets, or in those having a lower percentage of sugar.

The leaves of the sugar beet contain some glucose and maltose, but only small quantities, if any, sucrose.



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Bulletin 59.

December, 1900.

# The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

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AGRICULTURAL EXPERIMENT STATION,

INVESTIGATION OF THE GREAT PLAINS.

## FIELD NOTES

—FROM—

TRIPS IN EASTERN COLORADO.

—BY—

J. E. PAYNE.

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PUBLISHED BY THE EXPERIMENT STATION  
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1900.

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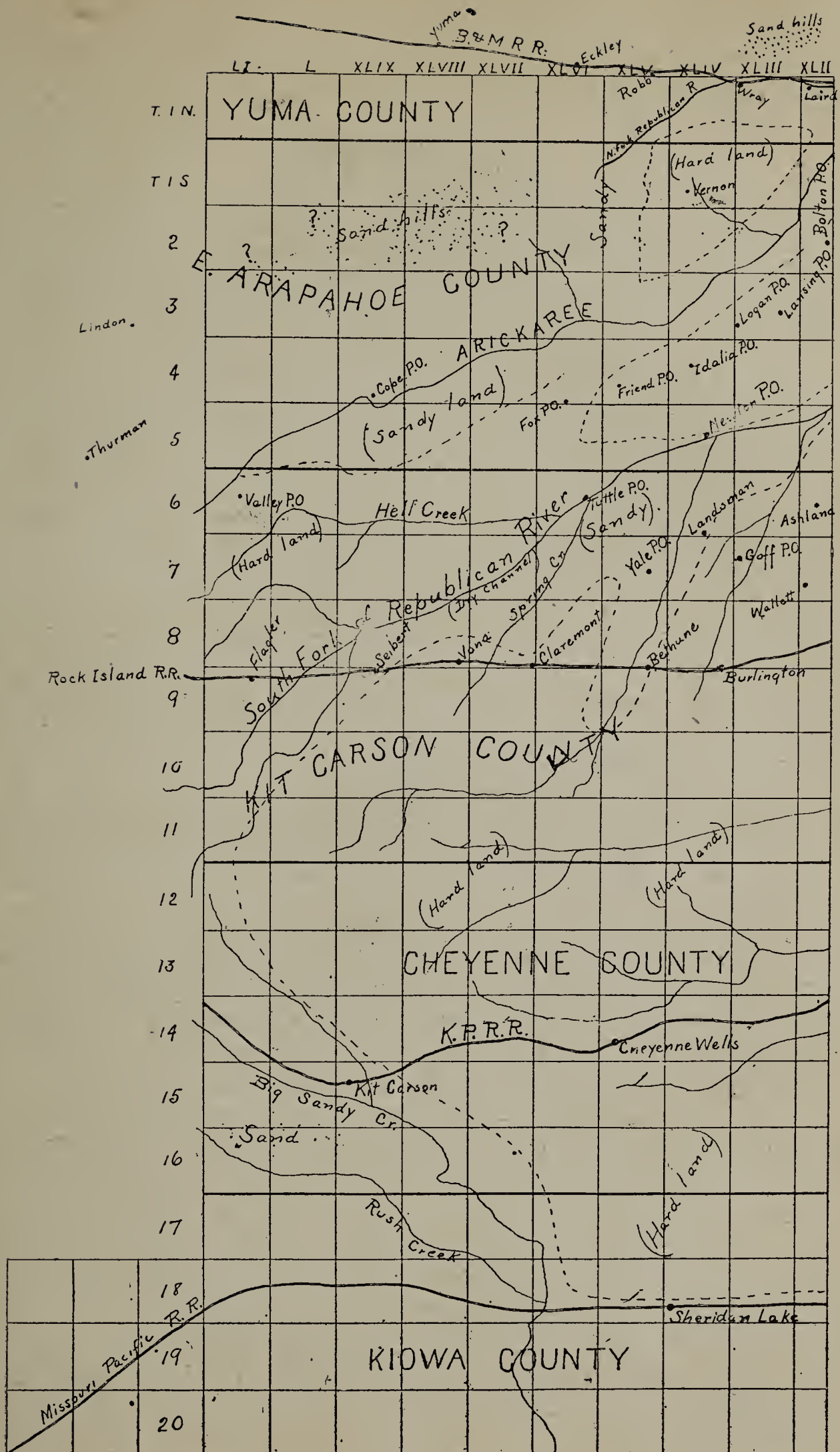
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MAP OF REGION EXAMINED.

## INTRODUCTORY.

Some years since (in 1894), a substation was organized at Cheyenne Wells, in Eastern Colorado, for the purpose of testing plants and methods adapted to that region. A report of the trials was given in the Annual Report for 1899. \*

During the past year a different plan of work was adopted, both because it seemed that greater results could be secured, and because the authorities at Washington had ruled that the maintenance of permanent substations was not contemplated by the Hatch Act. The work was lessened so that the superintendent had fewer duties at the station; he was furnished with a team, and his time largely given to a study of the methods of those who have gained a foothold, and to derive therefrom lessons of greater value than could come from the tests of a single person. The work of the year has been preliminary, but was necessary to establish a sound basis for future investigation or discussion of the problems of the Plains.

The reconnaissance covers only a small part of the Plains portion of the State, and, therefore, the statements are not necessarily true for the region outside that considered.

The Plains portion of Colorado extends from the eastern border of the State to the foothills of the Rockies. Fort Collins, Boulder, Golden, Colorado Springs, Florence and Trinidad are at or near the western border. Along the eastern border the elevation is from 3,500 to 4,500 feet, and along the foothills from 5,000 to 7,000 feet, the latter elevation being found on the Divide between the Platte and the Arkansas rivers. The Plains are thus an inclined plane, rising almost imperceptibly from ten to twenty feet per mile.

Limitless in expanse, with scanty, though nutritious, grasses, the Plains form the natural home of the stock industry, as they once did of vast herds of buffalo.

This is not the place to discuss the Plains problem. With an area greater than most of the states east of the Mississippi, the magnitude of the area justifies a serious examination.

L. G. C.

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\* Also issued as an excerpt.







SORGHUM ON OLD GROUND.



SORGHUM ON SOD.  
(Same row, planted same day as preceding.)



# INVESTIGATION OF THE GREAT PLAINS.

## FIELD NOTES

—FROM—

### TRIPS IN EASTERN COLORADO.

By J. E. PAYNE, M. S.

*Superintendent of the Plains Substation.*

This work was done by traveling about the country in a spring wagon. Over thirteen hundred miles were traveled during the progress of the work. Settlers were interviewed, and their evidence recorded. The investigation was confined mainly to Kit Carson county and the eastern half of Arapahoe county.

Contrary to my rule, I have recorded my opinions and impressions in this report. These opinions are based upon a mass of evidence which is almost too extensive to record.

With the exception of small areas near Idalia, and Vernon, stock raising is the principal business of the people. Those having small herds usually raise some rough feed for use during storms. The Vernon settlement seems to be the only one which has held its own and held to the idea of grain raising exclusively. Many near Vernon believe in stock raising, but the country is occupied so fully that there is no range for stock. At Vernon, and near Lansing, Idalia and Friend, sentiment has made a local herd law which persuades each man to fence or herd his stock during the growing season. In all other communities, crops must be fenced to protect the cattle, but in those neighborhoods, the saying has become proverbial that, "No one has ever known a wheat field to chase cattle to their injury." So if a man keeps stock, he must keep it away from his neighbor's crops. These people, living from one hundred and thirty to one hundred and fifty miles from their county seat, do not often feel the force or effect of ordinary State laws; so they have been forced to allow a few customs suited to their conditions to crystallize into laws, so far as it is possible in the time they have lived in these communities.

*Depopulation*—Almost the whole of Eastern Colorado was settled quite thickly during the years from 1886 to 1889. Lansing, Idalia, Friend, Cope, Arickaree City, Thurman,

Lindon and Harrisburg all aspired to be large cities, county seats or railroad centers. Lansing has disappeared and left only a few cellars to mark its site. Idalia still has two stores, two blacksmith shops, a school house and a few dwellings. At Friend, one old building, now used for the school, remains. Cope still has a store, a few dwellings and a school. One store building (now used as a residence by a family of four) still stands on the site of Arickaree city, and Arickaree P. O. is located on a ranch eight miles away. About Lindon, nearly all the land for miles around was once filed upon. Failure to get water in necessary quantities caused the whole country to be depopulated. At one place, I drove eighteen miles between Cope and Lindon without seeing a house. The site of old Lindon is now marked by a few heaps of earth and a few holes in the ground. Lindon postoffice is four miles south-west of the old town site, and the nearest house is two miles away. At Harrisburg, one family still lives. Thurman, also called Stone city, once had two banks, and two railroads were surveyed through it during "boom times." Now one family lives in Thurman. But a colony of hardy Mennonite farmers still hold claims near enough together to make lanes necessary. Two lanes cross at Thurman postoffice. These farmers are all getting to be quite well-to-do. They make stock raising their main business, but they usually raise grain, and always produce plenty of rough forage for their cattle. By these people, the Russian thistle is considered a friend. If the wheat crop fails, the Russian thistle grows among the wheat, and Russian thistle and wheat mixed make excellent feed. Before the introduction of the Russian thistle, they had no winter forage when their wheat crop failed.

#### **TREES—*Timber Claims.***

Of the thousands of claims planted to trees, only a few groves remain to-day in thrifty condition. I made it a point to visit every grove which was said to be in good condition and still cared for.

Observation has shown that groves cease to do well as soon as they are abandoned and permitted to become scratching places for cattle. After inspecting several hundred claims, we decided that the trees which have been able to withstand the conditions best are ash, honey locust and black locust. I photographed two of the best groves I saw. One of these is one-half mile west of Logan post office. The other is seven miles north-east of Lansing post office.



These have both been thinned to eight feet apart each way. They are nearly all ash trees. The tallest tree in each grove is an elm. The grove north of Lansing is on a high divide, while the one near Logan is on flat land where it may get some extra water.

There are many other places where small groves are still kept in good condition. Near Thurman, Mr. Joseph Schrock has a row of ash trees near his corrals which measure from thirteen to twenty-nine inches in circumference. These are planted where the snow piles up around them every winter. At the same place, a cottonwood tree growing near a water tank is kept in a thrifty condition by the waste water.

One of the most widely known of the groves on high prairie is that of Success Kerns who lives three miles northeast of Claremont. Intensive cultivation has been practiced, and no irrigation. Mr. S. L. Howell, near Vona, has raised some nice groves on the high prairie.

I have taken records of many other groves, but these are the ones that seem most likely to receive continuous care.

Of the trees growing where water is near the surface, Cope's grove, at Cope, on the Arickaree bottom, presents the best example. About twenty acres were planted to trees there during the years 1887—1890. Cottonwood, boxelder and ash are the principal varieties, between five and six acres of trees still remaining. The best part of the grove is cottonwood trees which grow where water is from two to five feet below the surface. Many of these are forty to fifty feet high, and some are three feet in circumference.

#### TREES—*Miscellaneous.*

The best example of how one may use the natural conditions, as slopes, ravines, and so on, to help trees and crops is found at the place of James Howell, who lives seven miles northeast of Flagler. The forest trees which are mainly black locusts are set in clumps and hedges so as to make a dense windbreak. The orchard is on the right bank of a creek which runs southeast. A well at the southeast corner of the orchard, supplemented by a small storm-water reservoir at the northwest corner, supplies water for irrigating, in a small way, where need is greatest. The ravine has been dammed and the extra water conducted past the grove through an artificial channel, leaving the old channel dry below a pond of water which at times is several feet deep.

The sides and bottom of this old creek bed were recently planted to fruit trees—mostly cherry trees. On one bank stand several plum, cherry and walnut trees which have reached the bearing age. Just above each of the trees on the bank is a large hole into which water from higher levels may flow during rains. The walnut and cherry trees bore good crops in 1900. Some apples were seen on the apple trees. The grapes, strawberries and currants also showed fair crops.

#### FRUIT TREES—*Not Irrigated.*

When the country was first settled, hundreds of orchards were set out. Lack of skill, bad nursery stock and drought reduced the number of orchards to one here and there where a combination of circumstances kept alive the hope that a successful orchard could be produced.

Many orchards were kept in good condition until 1893 at which time they were about five years old. The unfavorable conditions of 1893, 1894 and 1895 reduced the number of experimenters to a few, who were as stubborn as Colorado droughts. One of the best orchards given up in 1894 was that of A. C. Willis, three miles north-west of Kanarado. For a time, he had the best trees in the county, but dry weather and hail damaged his trees so badly that he became discouraged.

The following table gives a summary of the present condition of orchards on uplands, or where it is impossible to get sufficient water for irrigation. I include James Howell's place in this because he has made his success by taking advantage of natural conditions, just as hundreds of others could do if they would use the same amount of thought and labor.

It is generally conceded that cherries, currants, plums and gooseberries can be produced in moderate quantities without irrigation. Apples and peaches are not considered sure although some have been produced.

| <i>Owner.</i>    | <i>P. O.<br/>Address</i> | <i>Trees still thrifty.</i> |          |        |           | <i>Trees which have produced fruit</i> |          |        |           |
|------------------|--------------------------|-----------------------------|----------|--------|-----------|----------------------------------------|----------|--------|-----------|
| R. F. Davis,     | Vernon,                  | Apples,                     | peaches, | plums, | cherries. | Apples,                                | peaches, | plums, | cherries. |
| James Slick,     | "                        | "                           | _____    | "      | "         | "                                      | _____    | "      | "         |
| W. S. Calloway,  | "                        | "                           | _____    | "      | "         | "                                      | _____    | "      | "         |
| Joseph Miller,   | "                        | "                           | _____    | "      | "         | "                                      | _____    | "      | "         |
| Allan Smith,     | Wray,                    | "                           | _____    | plums, | cherries, | "                                      | _____    | plums, | cherries. |
| Wm. M. Barnes,   | Jagua, Kan.,             | "                           | peaches, | "      | "         | "                                      | peaches, | "      | "         |
| J. Brigham,      | "                        | "                           | "        | "      | "         | "                                      | "        | "      | "         |
| S. L. Howell,    | Seibert, Colo.,          | "                           | "        | "      | "         | "                                      | "        | "      | "         |
| James Howell,    | Flagler, "               | "                           | "        | "      | "         | "                                      | "        | "      | "         |
| P. J. Nicholls,  | Cope, "                  | "                           | _____    | "      | "         | "                                      | _____    | "      | "         |
| W. J. Brooker,   | Cheyenne Wells,          | "                           | _____    | "      | "         | _____                                  | _____    | _____  | _____     |
| The Plains       | "                        | "                           | peaches, | "      | "         | Apples,                                | _____    | plums, | cherries. |
| Substation,      | "                        | "                           | "        | "      | "         | "                                      | _____    | "      | "         |
| J. S. Johnson,   | "                        | "                           | _____    | "      | "         | _____                                  | _____    | "      | "         |
| J. B. Robertson, | "                        | "                           | _____    | _____  | _____     | Apples,                                | _____    | plums, | _____     |

Gooseberries and wild currants generally do well with-



out irrigation. I found grapes bearing at Peter J. Nicholls' garden and also at Joseph Schrock's. Grapes found in bearing at James Howell's place had received some extra water.

*Ornamental Plants*—We have found roses doing well without irrigation at several places.

#### IRRIGATED PLACES.

John Rose, who lives five miles northwest of Seibert, has been the most successful with a fruit garden of any one we have seen. He began by irrigating only a few trees and a few rods of garden. He extended the plat to include about one fifth of an acre which was watered from one well. The water was pumped by wind power from a well eighteen feet deep. Later, he dug another well and built a reservoir and extended his patch so as to include nearly two acres. We attribute his success to his ability to begin on a small scale and slowly enlarge as he learned how to handle his water economically, and as he found profitable market for his products. We shall file photographs\* of an apple tree and a plum tree as they appeared in his orchard in September 1900, also a photo of his reservoir. Charles Blake and James H. Priest who live in the same neighborhood are making a success of their irrigated fruit gardens also. All raise apples, plums, cherries, gooseberries, currants and strawberries. Mr. J. C. Cope, at Cope, has a good fruit garden which is irrigated from a well.

But the most successful irrigation where deep wells are used, is that of Peter Eckert who lives about four miles southeast of Thurman. His two wells are each one hundred and twelve feet deep. The water is pumped by windmills into reservoirs for storage. The pumps run day and night to water about two acres and supply water for a large herd of cattle. The place is located on a hill. All the ground irrigated is nicely terraced so as to use the water to the best advantage. One part of the place is laid out for ornamental plants and a vegetable garden, another for fruit trees, excluding apples, another is the apple orchard, and the other is planted to grape vines. Hail and wind has prevented the production of much fruit of any kind. But the place is well kept notwithstanding the fact that it does not give large financial returns. The owner loves his trees and vines as he does children. He is too feeble to work in the field, so he spends nearly all his time with his trees and his garden.

A few who live around the south fork of the Republican

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\* Not suitable for reproduction.

or its tributaries, water their trees and gardens from ditches. Among the most successful of these are G. B. Kuk and Wm. P. Baily near Newton, and C. Waline who lives about five miles southwest of Jaqua. Mr. Waline uses a storage reservoir in connection with his ditch. He also uses a well to help out in times of scarcity.

Those who are using windmill power to pump water for the irrigation of vegetables are too numerous to mention, but the really successful plants are few. The main trouble is that they usually attempt to do too much—spread over such a large area that when crops are most in need of water the supply is insufficient.

I saw one place where a man had built a reservoir and planned to irrigate five acres of very sandy land from one well. When the supply of water is sufficient we sometimes find that insufficient reservoir space is another weak point. The wind may refuse to blow during the driest weather of the summer, and when it does blow, the water is often applied to the crops just as it comes from the well. This chills the roots and checks growth.

But the cause of the abandonment of many successful small irrigation plants has been the increase of the herd of cattle kept to be watered from the same well upon which the garden was dependent for its supply.

*Storm Water from the Prairies*—Mr. W. V. Erickson, who lives three miles southeast of Burlington, is one of the most successful of those who have watered gardens from wells. He has planned to catch the storm water from several hundred acres of prairie in a reservoir which he was making when I visited him. We shall watch the result of his work with interest. Mr. James Howell, near Flagler, who was mentioned before in the discussion of trees, has the only storm-water reservoir which we saw in operation. His main reservoir would be likely to benefit his trees mainly by the seepage of water down the old creek bed, thus furnishing natural sub-irrigation.

#### IRRIGATION DITCHES.

There are two ditches in the valley of the South fork of the Republican river. These were planned to supply water to large areas; but they seem to be failures. Small ditches water considerable areas planted to alfalfa near Tuttle, Landsman and Newton. A few small private ditches are successfully operated on the lower part of the Arickaree. One very successful ditch is operated in the valley of the North fork of the Republican.



## UPLAND FARMING.

In every community through which I have traveled, except small areas near Idalia and Vernon, stock raising is considered the principal part of farming. Other communities are in various stages of transition from grain to stock raising.

*Cheyenne County*—All given over to stock raising and practically no grain raising attempted.

*Kit Carson County*—I divide into districts as follows:

1. All south of the Rock Island railroad and nearly all west of Claremont given over to stock with but little grain raising.

2. Yale, Wallet, Goff, Ashland and Burlington—Stock raising is considered first by practically all the settlers. But some plant grain hoping to harvest a crop if the season is favorable; but if the season is unfavorable, they expect a crop of forage from the grain fields.

3. Valleys of the Landsman and South fork of the Republican—Nearly all occupied by stock men before the wave of settlement came. Still given up to stock exclusively, except a few places near Seibert where men have obtained a foothold and are developing horticulture on a small scale. Alfalfa-growing is quite general wherever there is water enough for irrigation.

*Eastern Arapahoe County*:

1. Lindon—Given up to stock exclusively.

2. Thurman—Grain is sown quite extensively. There is some threshing done nearly every year. When the season is unfavorable for wheat, it is a good season for Russian thistles. The wheat and thistles are cut for hay, and make good feed when used together.

3. Kirk and Fox—On the border line between a stock raising district and a grain-growing district. Here we find that nearly all are still raising grain; but all are getting into the stock raising business as rapidly as their means will permit.

4. Friend, Idalia, Logan, Lansing and Bolton—This district is devoted to grain growing. But there is a strong sentiment in favor of stock raising exclusively wherever large areas are available for free range.

5. Vernon—This district is devoted to grain growing. Some people own cattle which are kept in the sand hills during summer and brought in to winter around the straw stacks. Many around the edges of this settlement favor stock raising exclusively.

6. The Sandhills in Eastern Arapahoe—This district is devoted to stock grazing exclusively.

7. The valleys of the Arickaree and the South fork of the Republican river are devoted to stock raising exclusively.

*Yuma County*—That part of Yuma county lying on the divide between the north fork of the Republican and the Arickaree belongs with the Vernon neighborhood. The valley of the North fork of the Republican is used mainly for stock raising. The fields of alfalfa furnish winter feed for cattle which are kept in the sandhills on the north of the valley.

#### CROPS RAISED.

*Sorghum*—Generally grown where stock raising is the main business. Many cattle men object to it on account of the heavy work required to harvest it. Yield from one-half to four tons per acre. Average probably one ton per acre.

*Broom Corn*—Usually successfully raised. Uncertainty of price has prevented extensive planting.

*Millet*—Quite a general favorite among cattle men. They claim that it requires less exertion per ton to raise and harvest millet than any other cultivated crop. Yield from one-fifth to two tons per acre.

*Corn*—Corn is generally planted in small areas in nearly all neighborhoods investigated. Many claim that if the season is favorable, corn can be raised cheaper than it can be bought. But if the season is unfavorable, a crop of fodder will be raised. The average yield is best on black, sandy land. Yields as high as fifty bushels per acre have been reported. The usual yield is from two to twenty-five bushels, while the average for the whole region will not exceed ten bushels per acre.

*Oats*—Usually considered an uncertain crop. Less popular than wheat or millet. Considerable is sown for hay in some places. Reported yield per acre from nothing to thirty-five bushels. Probably the average is near ten bushels per acre.

*Wheat*—The most popular of small grains. Reported yields from nothing to forty bushels per acre. The general average yield per acre for the region is probably about six bushels. Some have reported average yields of eleven bushels per acre, including twelve years cropping. From observation, I believe the men who produced these crops to be far above the average as farmers, and so cut down my estimate of the average yield accordingly.

*Barley*—A crop which is but little grown, as compared with wheat. Many consider it the surest grain crop that has





GROVE OF MILTON MORRIS, NEAR LANSING.



GROVE OF HUGO KURZIDIM, NEAR LOGAN.  
(Tallest tree in each case is an Elm.)





been tried. Yields of eighty-three bushels per acre have been reported. The average yield is estimated at fifteen bushels per acre. The variety planted is mostly "California Feed" barley, and it is used at home for feed almost exclusively.

*Rye*—This crop is but little grown. Not enough found upon which to base an estimate. But, in 1899, a crop was grown on a field of black sandy soil near Cope which yielded seventeen bushels per acre. No rain fell upon this field between seeding and harvesting.

*Flax*—We have found men near Ashland and Thurman who have raised good crops of flax. So few raised it that what was raised was not readily sold, so production ceased. It has not been generally tried.

*Native Hay*—The valleys of the North branch of the Smoky Hill river, the three valleys of the Republican, the valley of the Big Sandy, and the Sand hills furnish considerable native hay every year. We made no attempt to make a collection of native hay plants this year. Hay is usually cut about two years in every five on the uplands. This consists mainly of several species of grama grass and Colorado bluestem (which is known also as bluegrass, elk grass, June grass and probably by several other names.) In traveling over the county, I noted that Colorado bluestem is taking possession of land which has been broken, and abandoned. It appears to successfully dispute the right of occupancy with the Russian thistle. We have also seen it invading uncultivated timber claims and growing quite rank among the trees.

*Russian Thistles*—Russian thistles are quite common in all the regions studied except in about two townships near Idalia and five near Vernon. Wherever the Russian thistle has obtained what seems to be a permanent foothold, the settlers are using it quite largely for forage. Thousands of tons of it are now stacked up for use during the winter. We issued a press bulletin concerning "The Russian Thistle as a Forage Plant," in July, 1900. This bulletin was widely quoted.

*Salt Weed*—(*Atriplex*, sp?) This plant is found on the upper part of the South fork of the Republican as far down as Seibert, and in the western half of Cheyenne county. It seems to prefer an adobe soil containing considerable alkali. The stock that range where it grows do not eat salt, as they get enough salt to supply their needs by occasionally taking a bite of salt weed.

Wm. Lang, who lives near Cheyenne Wells, made hay

of "salt weed" several years ago. He reports that his sheep did well on it. Last year, a cattle man on the South fork of the Republican put up some for hay. He reports good results. September 22nd., 1900, I photographed a rick of salt weed one hundred and twenty feet long. This was put up by Mr. Thos. McCallum who lives ten miles south of Arriba. He intends to give it a thorough trial this year.

#### SOIL STUDY:

As I traveled I examined the soil by occasionally boring and noting the appearance of the soil and sub-soil.

A traveler could go from Sheridan Lake in Kiowa county to Wray in Yuma county (one hundred and ten miles) and think he was traveling over the same kind of soil all the way, except short stretches on each side of the larger streams. The whole distance traversed would be on practically the same kind of soil which is known locally as "hard land." It has enough clay in it to make a good road bed. This land sustains a growth of the short grasses—as buffalo grass and grama grass. Along the streams is found a sandy soil upon which sage brush is the principal vegetation.

This "hard land" is the principal type found on all the uplands of the region investigated. Between this upland soil and the valleys is usually a strip of sandy soil which may be from a few feet to several miles in width. The river valleys proper frequently have an "adobe" upon which "alkali grass" grows. Usually where "alkali grass" does not grow the soil is too sandy for profitable cultivation. The sandy soil is usually considered best for corn, while the "hard land" is thought to be best for wheat.

#### METHODS OF PLANTING AND CULTURE.

*Corn and Sorghum*—The lister drill is generally used for planting corn and sorghum. After planting, the harrow is used by many until the plants are so high that the harrow may break them down if used. Weeders are coming into use also. We find many who advocate frequent culture to preserve a "dirt mulch" on the top. This is supposed to require stirring the ground after each rain, and occasionally during prolonged droughts. But many object to doing this because it requires too much labor.

Observations made during this year have confirmed my belief in the value of a "dust mulch," but I am also convinced that the "dust mulch" may be just as valuable when covered by a light crust such as is formed by a light rain as when no



crust is allowed to form. I saw dust blankets on prairie where no tool had ever tickled the earth.

Once, when crossing a sandy stretch of country, I saw some fields of corn which were looking healthy, notwithstanding the fact that no rain had fallen for several weeks. The corn had not been cultivated for at least a month; so I examined the soil in the corn. I found a light crust, then a dust mulch from two to three inches thick and below that, moist soil. I then turned to the unbroken prairie and found practically the same conditions. I afterwards examined dozens of cornfields and found the same conditions wherever the cultivation had been thoroughly done, even if it had been several weeks since the soil had been stirred.

*Millet*—Methods of planting differ widely. Practically all seeding is done broadcast. Some plow shallow, some do not plow at all, but broadcast the seed and cover with the disc harrow afterwards. Results reported to be about the same from all methods.

*Small Grain*—It is generally agreed that small grain does best when sown on ground which has been cultivated the year before in some hoed crop. The most generally used method is to broadcast the seed on unprepared land (not plowed or disced but the sod broken, of course) and cover with disc harrow or cultivator. Some use disc press drills and some use the other kind of drills. There are men who hold to each of the methods.

Some claim that they have always harvested heavy crops when enough rain fell at the right time, no matter how the grain was put in; and that they never got anything when the season was against them no matter what method they had used.

*Pests*—The two pests which do the most damage to crops in the region investigated are potato beetles (*Meloidae*) and grasshoppers. There are few years when the settlers could not raise enough potatoes to supply the local markets if the crop could be protected from the potato beetles and grasshoppers.

In 1896, one man had to move his cattle to another range on account of the ravages of a variety of grasshopper which ate grass exclusively. This year I saw many fields of grain which were badly damaged by grasshoppers. They reduced the yield harvested, by cutting the heads off the wheat and oats before the grain was ripe enough to cut.

#### CONCLUDING OBSERVATIONS.

Natural conditions seem to have fitted this region for a

grazing country, but the hardships encountered by people in gaining a living in the crowded eastern states have pushed people into what the cow-man once thought his exclusive domain. After settlers got in, many found that, hard as conditions were on the plains, they could do better here than they could with the same capital in any other place with which they were acquainted. These men have built themselves homes, and, in a measure, made the nomadic life of the old-time cow-boy an impossibility in the future.

Nearly all the settlers have been compelled to turn their attention to stock raising, on account of crop failures during some years and low prices other years. The main drawback to grain raising in the region near Idalia is the distance from market. All wheat raised on that divide must be hauled in wagons from thirty to forty miles. Considering these factors, almost any business farmer would decide to raise crops which could walk to market, or crops which could be condensed. And nearly all who live there believe in doing this, even if they do not practice it.

At present, on account of the demand for beef cattle and the confining work connected with dairying, only a small amount of butter is produced. But when the price of cattle goes down again the same natural business law which has forced people to go into cattle raising will compel them to turn their attention to the production of butter and cheese. Free range, cheap rough feed and inexpensive warm stables will help them to make winter dairying profitable. When they get to this, all products will be sent to market in condensed form, and the importance of the problem of transportation will be reduced. The country can then support sufficient population to supply good schools for the children. Each family can have a small garden, a few fruit trees and some small fruit for home use. These can be irrigated from a well. Natural conditions, such as are used by Mr. James Howell, will probably be taken advantage of more freely than at present. People who are either unwilling or unable to adapt themselves to the new conditions will move away, and their places will be taken by others who are better adapted to the conditions.

The valleys of the Big Sandy, the South fork of the Republican and the Arickaree may someday support quite a population. Much of the land near these streams is too sandy for profitable farming. But, if those streams were turned out of their courses and the water taken out into the uplands, and the storm water stored in reservoirs, large bodies of good land might be irrigated and hundreds of homes maintained in what is now merely a cattle pasture.



Bulletin 60.

December, 1900.

# The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

AGRICULTURAL EXPERIMENT STATION

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UNIVERSITY OF ILLINOIS.

## BUSH FRUITS,

INCLUDING

GOOSEBERRIES, RASPBERRIES, BLACKBERRIES,  
DEWBERRIES.

—BY—

CARL H. POTTER.

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\* Died December 9, 1900.



## A VARIETY TEST AND GENERAL REMARKS

— ON —

# BUSH FRUITS.

CARL H. POTTER.

### GENERAL REMARKS.

It is not the intention in issuing the present bulletin to go deeply into a consideration of the culture and general management of bush-fruit plantations. This information comes to the practical growers from many sources.

Good and abundant cultivation and irrigation is of prime importance. A naturally cool and somewhat moist soil is desirable, and in the hotter portions of the State a partial shade is often necessary. This shade is sometimes obtained by planting the bushes near shade trees, or even in orchards, but this latter practice is not always looked upon with favor by our best orchardists. Again, simple mulching is used.

The rows should be placed at a liberal distance apart and the hills should not be crowded in the rows. A few good, vigorous shoots should be grown, thus better to resist the ravages of the increasing number of our insect and disease enemies.

Prof. Gillette, in Bulletin No. 47 of this station, names five or six insect enemies which are injurious to our bush fruits. Of these, perhaps the worst two are the currant-borer, *Sesia tipuliformis*, and the saw-fly, *Pristophora grossulariæ*. The former is easily removed and destroyed by the usual annual pruning, thinning and burning of the old canes. The larvæ of the saw-fly are easily destroyed by the common arsenical sprays.

The ravages of the fruit-worm will be spoken of in connection with the fruits injured.

Diseases of the plants have but recently become of economic importance on our grounds. They will furnish material for future study and publication.

Our present plantations of bush fruits contain about

seventy varieties. A few varieties disappeared from the test-plats during the last three years, other varieties planted failed to become established, and still others were planted only last spring.

The older plantation was set in 1896. Other plants and other varieties were added in 1897 and in 1898, and a new plantation set in 1900. In so far as the blackberries and raspberries are concerned, these latter years enter comparatively little into the description or tests of plants or fruit which follow. The season of 1898 was so extremely dry that the water for irrigation purposes was entirely inadequate to the development of either fruit or vine.

This season of drought was followed by the extremely early and severe winter of 1898-9 which prevented the proper covering of the vines, resulting in the complete killing to the ground of all the raspberry and blackberry canes, thus preventing a crop in 1899.

The canes of all the raspberry and blackberry vines were pinched back when about 18 inches in height, the result being a fine growth of well-matured stocky canes. They were laid down by removing the earth from underneath one side of the hill and forcing the tops in that direction with a fork, then covering to a depth of about 3 inches with earth. By a yearly practice of this method the roots extend laterally and are but little injured in the process of laying down, while the canes, though stiff and stout, are but little bent and are therefore uninjured.

Winter protection is the only safe course to follow in this section of the state.

#### GOOSEBERRIES--*Ribes*.

Even some of the currants and gooseberries suffered more or less severely by the extreme winter of 1898-9. A record of this injury follows in the notes on the individual varieties.

The gooseberry plantation consisted of six varieties, one of which, Industry, is now extinct. As there has been such a great difference in the age and vigor of the several varieties, it is thought best for the present not to append figures giving the comparative yields.

Three varieties new to the plantation were added last spring.

The gooseberry crop of 1900 was, from a commercial standpoint, almost totally destroyed by the ravages of the fruit worm, known to science as *Epochroa Canadensis*. The "worms" are the larvæ of a two-winged fly which deposits



its eggs underneath the skin of the fruit while the latter is still quite immature. Within the fruit, where they are quite safe from insecticides of all kinds, the larvæ grow to maturity. The fruit becomes worthless. The only known remedy is to destroy the fruit while it still contains the larvæ.

Following are the varieties tested:

**Downing—*Ribes cynosbati*.**

Some old bushes were reset in 1896 and some young ones in 1898. The bushes are upright in growth with stiff stocky branches, spines stout and prominent, berries medium to large with a conic, dark green apex, and covered with a heavy glaucous coat. Yield good. The variety was very severely killed back by the cold winter. All the hills, old and young, are looking remarkably vigorous now.

**Houghton—*R. hirtellum*.**

Of this variety some old bushes were reset in 1896, to which were added new bushes from the nursery the same year.

The variety is a vigorous grower with long, slender, spreading branches, spines slender, berries small to medium, surface glaucous, obconic form, deep green color, very sour, yield very good—fully a week later than the other varieties in the plat.

The old canes are fairly stocky and well loaded with fruit buds, but the variety is not nearly so strong and vigorous a grower as is Oregon Champion. Very little injured by the cold winter.

**Industry—*R. grossularia*.**

Young plants of this variety were set in 1896, to which were added some old bushes reset the same spring. The variety is of European origin. The leaves are dark green, leathery, with a lustrous surface. The thorns are short and stout and frequently there is but one at the base of each leaf-stalk instead of the usual cluster of two or three. The berries are large, oval, veins conspicuous, with a considerable number of bristles on the surface. The variety entirely succumbed to the mild winters of '96-7 and '97-8.

**Oregon Champion—*R. grossularia*.**

New plants of this variety were set in 1896. The variety is of spreading habit with rather large, stiff and stocky branches. The leaves are somewhat more glaucous and darker green than are the leaves of other varieties. The berry is large, oval, with a glaucous surface. The variety was apparently very little injured by the excessively cold winter of '99 and bore an excellent crop of fruit the next season. It is a most desirable variety on account of the vigor of the plants and the yield of fruit.

**Pearl—*R. grossularia*.**

Young plants of this variety were set in the plat in 1897. They made a good healthy growth during that and the following season. The winter of 1899 killed the canes to the ground and they were cut-out. The growth the past two seasons consists of many vigorous and well branched canes.

**Smith's Improved—*R. grossularia*.**

Old bushes of this variety were reset in 1896. The variety is fairly vigorous and was not entirely killed back by the winter of 1899. It was severely pruned and made a fair growth during the past two seasons. Berries very large—largest on the grounds—quality good to excellent; long, oval form Translucent, with conspicuous lighter-colored veins.

## CURRENTS--*Ribes*.

The station plantation of currants consists of eighteen varieties, fifteen of which belong to the species *rubrum*, one Dubett Tree being *Ribes aurium* and two *Ribes nigrum*. The latter with four varieties of *rubrum* were set only last spring.

The red sorts are for the most part very similar, it being quite difficult to distinguish between them either by their fruit or the character of the plants. Where old bunchy varieties were set along with those trained to more of a tree form, the latter invariably produced larger fruit, but not so large a yield. The more abundant the fruit, the smaller the berries. The crop of fruit was, commercially speaking, a complete failure the past season owing to the ravages of the insect mentioned in connection with gooseberries. Much of the fruit fell before time for picking. Of that which remained on the bushes till the sound fruit was mature, from 25 to 60 per cent was stung and contained the larvæ of the fly. No such extensive damage appears on our previous records. Some plantations in this vicinity were comparatively uninjured.

The varieties of currants tested on the station grounds follow in alphabetical order:

### Albert Prince.

This variety is but slightly represented in the Station plat. It is considerably lacking in vigor and has been kept closely pruned for propagation purposes. The berries are of good size, white, and sweet.

### Cherry.

Both old and young plants were included in the 1896 plat, to which were added young plants in 1898. This red variety produced the largest berries of any variety on the grounds in 1896, and a good yield withal. Some of the berries measured 9-16 inches in diameter. The stems or branches are a little stronger than Fay, but not nearly so strong as Red Dutch or Victoria.

### Dubett Tree—*Ribes aurium*.

One plant of this variety was set in the plat in 1897. It has made a vigorous growth, quite upright in character. Although the wood appears to ripen well, yet the leaves near the tips remain quite fresh and green till mid-winter or later. The variety is being propagated by cuttings and the number of plants will be increased in the near future.

So far the fruit produced has been quite insignificant.

### Fay.

Both old and young plants of this variety were set in 1896. The variety is not nearly so strong and vigorous as either Victoria or Red Dutch. It produces a great many new canes of spreading and unkempt habit. The injury from the winter of '99 was considerable. Berries red, medium to large. Yield fair to good.

The variety requires extra care to justify the recommendations so frequently given it.



**Holland—Long Bunch.**

This old sort was not introduced to our plantation till 1897, and then by very few plants, which have since been very closely pruned for propagation purposes. The plants are fairly vigorous, berries of good size, white, and sweet.

**North Star.**

A few old plants were set in 1896, followed by young plants in 1897 and in 1898. This variety was somewhat injured by the winter of '99. It is strong and stocky, but not nearly so much so as is Raby Castle or Victoria. It is much like Red Dutch in size and bearing propensities but is later in ripening.

**Pomona.**

But a few plants of this variety were set in the Station plat in 1897 and these have been closely pruned for propagation purposes.

The variety seems to be below the standard for vigor and was very severely killed back by the cold winter. It is a red variety.

**Raby Castle.**

Old plants of this variety were set in the Station plat in 1896 and young plants in 1898. It is considered by Prof. Card in his handbook on "Bush Fruits" of "The Rural Science Series" to be identical with Victoria. On our ground the two have every appearance of being one and the same variety.

**Red Dutch.**

Both old and young plants of this variety were set in 1896. It is an old standard sort and one of the best as to bearing propensities, but the fruits are smaller than are the fruits of the more recently introduced varieties. While this variety endures neglect well, yet with good culture and pruning the berries are medium to large in size. It is much like Victoria, but taller and more slender, producing new shoots in abundance. It was apparently uninjured by the recent cold winter.

**Versaillaise.**

Both old and young plants of this variety were set in 1896. It is nearly as vigorous a grower as Red Dutch, but there are many more shoots which are quite unkempt in habit—much like Fay in this respect, but not so exaggerated. Injury by winter of '99 very slight. Berries are large, spherical, red, rather more acid than our other varieties.

**Victoria.**

This is the champion variety of the plantation. Set in 1896. Although producing no more fruit than some of the other sorts, it is very strong, vigorous, upright in character and its freedom from the production of many shoots render it a very desirable variety. The fruits are of medium size, red, mildly acid—remaining for a long time on the bushes.

**White Grape.**

This excellent white variety was reset and new plants added in 1896. The bushes are a little shorter and more stocky than Versaillaise with not quite so many shoots. Stems are somewhat inclined to be prostrate. Apparently uninjured by the cold winters. Berries are large, of a translucent yellowish white color, growing in long bunches, but sweeter than most red sorts—a good bearer.

Probably the best white currant on the market at the present time.

**RASPBERRIES—*Rubus*.**

Partial reports upon twenty-three varieties of raspberries follow. It is to be regretted that the record of fruiting

is not more complete; but, as stated under the general head "Bush Fruits," this lack of data is principally due to the unusual climatic conditions of 1898 and 1899. Following an extremely wet April, the season of 1900 was unusually hot and dry.

While authorities differ greatly concerning the proper position or location of our various cultivated varieties of raspberries and blackberries within the genus *Rubus*, yet probably the great majority accept the classification given by the American Pomological Society. According to this, raspberries are divided into four species, the European red varieties being *Rubus idæus*, the American reds *R. strigosus*, the black-caps *R. occidentalis*, and the purple canes which are considered to be hybrid between *R. strigosus* and *R. occidentalis* with all degrees of tendency toward either parent, are classified as *R. neglectus*. The purple canes, as a class, are propagated by the tips, and very little, if any, by suckers.

#### **Brandywine—*R. strigosus*.**

This old red variety was not introduced to the Station grounds till 1898, consequently there are no adequate notes upon the fruit. The plant is stocky with large reddish colored canes which sucker freely.

#### **Carman—*R. occidentalis*.**

This excellent black-cap variety was set in the present plat in 1896. It is an extra early variety. Plants not large, but sufficiently robust. Berries medium size, mild flavor, juicy—in full bearing the latter half of July.

First ripe, July 3; last picking, August 2; full pickings, July 12-19.

#### **Columbian—*R. neglectus*.**

This is considered to be one of the leading varieties of the purple canes, being very much like the Shaffer in appearance—a very strong and vigorous grower. It is said to be a very prolific bearer, the fruit being a little later and larger than Shaffer.

#### **Cuthbert—*R. strigosus*.**

This old standby of the American red type has not yet been excelled on our grounds, although growing alongside the Marlboro. The plants in a part of one row of Cuthbert were carefully removed and Marlboro set instead, but the latter have been nearly exterminated by Cuthbert plants coming from old underground canes. Cuthbert leaves are narrower than are those of Turner, the latter being especially broad and showing much more color upon the upper surface while young than do Cuthbert leaves. Cuthbert canes have a considerable number of small prickles. Berries are large, dark crimson, broad, conic, grains small and compact. The flesh is good quality, firm, standing up well when picked in quart boxes. First picking, July 10; last, August 23; full picking, July 19 to August 5.

#### **Golden Queen—*R. strigosus*.**

This is considered to be simply a sport of Cuthbert, differing from it principally in the yellow color of its fruit.

#### **Gregg—*R. occidentalis*.**

This has long been the standard black-cap. Although perhaps a little



slower in attaining to full development than some other varieties, the plants are very large and vigorous, giving an excellent yield. The leaflets are especially broad. Berries are large, roundish, oblate with a decided gray bloom; firm, juicy and of very good flavor. The variety is late in ripening, giving the first picking at the Station about July 21.

**Hansell—*R. strigosus*.**

This, at one time popular American red variety, was not introduced to the Station grounds till 1898, consequently there is scant data as to its fruiting qualities.

**Hilborn—*R. occidentalis*.**

This black-cap is quite popular in Ohio and Ontario, but with us it has not done well as yet, although the fruit is near medium size and quite sweet and juicy. First ripe, July 21; last, August 2.

**Kansas—*R. occidentalis*.**

This variety seems to be the closest rival to the Gregg upon our grounds, although in time of ripening it more nearly coincides with the Carman. The plants are of rapid, vigorous growth, berries similar to Gregg, fully as large, ripening a week earlier; juicy, excellent flavor, quite firm; yield good.

First picking, July 10; last, August 2; heaviest, July 19.

**Loudon—*R. strigosus*.**

This popular Wisconsin berry was originated at Janesville, being a cross between Turner and Cuthbert. It has not yet fruited on our grounds.

**Marlboro—*R. strigosus*.**

It is probable that this extremely popular red variety contains an admixture of European or Idæus "blood." By some authorities it is classified as a hybrid between the two species.

This variety has done rather better in neighboring grounds than on the station plat. It is a vigorous and productive early market variety and a thoroughly good all-purpose berry.

**Mills—*R. occidentalis*.**

This black-cap variety was set in the Station plat in 1898 and has not yet been fruited. The variety is thought to be a cross between Gregg and Tyler.

**Miller—*R. strigosus*.**

Set in Station plat in 1898; not yet fruited. The variety is of the Brandywine type, but said to be considerably earlier.

**Mohler—*R. occidentalis*.**

This promising black-cap variety was set in the Station plat in 1898 and has not yet fruited. It is claimed to be a seedling of the Eureka, although considered by Prof. Green, of the Ohio Experiment Station, to be practically, if not actually, identical with that variety. It is certainly deserving of trial.

**Ohio—*R. occidentalis*.**

Introduced to Station grounds in 1898; not yet fruited. An established early variety in many sections. Much used for drying and for shipping fresh.

**Palmer—*R. occidentalis*.**

Introduced to Station grounds in 1898; not yet fruited. This variety originated in Ohio and has been reported favorably from many sections in the West, and seems to be well worthy of trial here.

**Pennock—*R. occidentalis*.**

A black-cap of medium slender habit originated by Mr. Chas. E. Pennock, of Bellvue, Colo. The plant is a good, healthy grower, but has not yet fruited on our grounds.

**Royal Church—*R. strigosus*.**

While classified as an American red, it is quite possible that this variety is a hybrid and should be placed with the *Rubus neglectus* group.

It is a very large and vigorous variety with purple canes, although producing suckers quite freely. Berries are very large, dark crimson, excellent quality, medium firm, stand up well in quart boxes, but are inclined to crumble. It produced the heaviest yield of any variety on our ground in 1897.

First picking, July 21; heaviest, July 31; last, August 23.

**Shaffer—*R. neglectus*.**

This is an extremely vigorous variety of the purple cane group, of which it is the type. While propagating by root tips, the bushes and also the berries resemble the red raspberries more than they do the black, although the berries grow in clusters much like the black-caps. The berry is large, dark red or purple, moderately firm, nearly as good quality as the reds and richer. It is an excellent variety, but is used more for drying and for canning than for using in a fresh state.

This variety is difficult to lay down unless it is trained to the operation from the first year.

**Strawberry-Raspberry, or Rose-Leafed Raspberry—*R. rosæfolius*.**

This variety is merely a horticultural novelty in this country. The species is found growing wild in Japan and Eastern Asia. It is of no value except as an ornamental plant and has not endured on our grounds even with winter protection. The summer heat seemed too intense for it.

**Thompson—*R. strigosus*.**

One of the American reds. Introduced to Station grounds in 1898. Not yet fruited.

**Turner—*R. strigosus*.**

This is a very vigorous, almost thornless variety, which was very popular for many years. The principal objection is that the berries are rather soft. Berries large, dark red, medium to large, of good quality and yield. The yield is very steady for the first three weeks, the picking season with us being July 10 to August 11.

An excellent variety for home use.

**Japanese Wineberry *R. phoenicolasius*.**

Set in the Station plat in 1898; failed to fruit; died 1899. It is doing fairly well on some grounds in this section, but is of no commercial value. It is a vigorous, semi-trailing bush of handsome appearance, but so far as fruit is concerned will be of interest only to those who are interested in horticultural novelties. The species is found growing wild in Central and Northern Japan and has long been grown in this country as an ornamental. It was not boomed as a fruit plant till 1889-90.

**BLACKBERRIES AND DEWBERRIES—*Rubus*.**

But four types of blackberries enter into consideration in this section, viz: 1, the Long Cluster; 2, the Short Cluster; 3, the Loose Cluster, which are thought to be hybrids between the first two and the common Dewberries of the Eastern states; 4, Northern Dewberries. The tendency



among the best growers of this section at the present time seems to be toward the 3rd class, which are more slender and flexible than the high bush varieties, but which, nevertheless, with proper pruning, hold their fruit well off the ground. All of this class that have been grown on our grounds seem to propagate quite freely by suckers and not by root-tips as is characteristic of Dewberries.

The common high bush berries are classified botanically as *Rubus villosus*, and Dewberries as *Rubus canadensis*. Most of the slender-caned loose-cluster varieties being evidently hybrids, are classified as *Rubus villosus* x *canadensis*?

Our old plantation was located on a hot and dry southwest slope, a very improper location, especially in connection with the fact that our supply of water usually fails about the time it is needed for the maturity of the fruit. As a result of these conditions the old plantation has been practically uprooted and a new one in a different location established. Many varieties new to the grounds, as well as all of the old ones, were set in this new plat, the rows of blackberries alternating with rows of black raspberries.

**Agawam—*R. villosus*.**

This variety is a representative of the short clustered group. It was introduced to the Station grounds in 1896, but has not yet borne fruit of consequence. We had an excellent stand of good thrifty plants. The variety is very popular in many sections; early in season and fruit of excellent quality.

**Ancient Briton—*R. villosus*.**

This variety is of the long cluster type. It was imported from England into Wisconsin somewhat over forty years ago, where it received its name and afterwards became very popular. It was introduced to our grounds in 1896, where it has obtained a good foothold, but has not yet fruited to any extent.

**Dallas—*R. villosus* x *canadensis* (?).**

This blackberry closely resembles the dewberries and is probably either the native Texan dewberry or a hybrid closely resembling the dewberries. The vines are much more upright than are those of the Lucretia or the Mayes Dewberry. The variety has made a good growth on our grounds, but has not yet fruited to any extent.

**Eldorado—*R. villosus*.**

This variety of the long cluster type originated in Ohio some time prior to 1882. The plants have made a good growth on our grounds, but have not yet fruited.

**Erie—*R. villosus*.**

This is a variety of the short cluster type originating in Ohio in 1876. The plants are thrifty, lighter green in color than our other varieties, producing a fair yield of fruit. Ripens mid-season, fruit large, short-oval, good quality.

**Mayes—*R. canadensis*.**

Although originating in Texas, this dewberry is of the Northern type. It has also been sent out under the name of Austin's Improved and reached

our grounds under that name, but these plants failed to become established. The variety propagates by tips and by root cuttings. With us the plants are quite strong and vigorous and appear promising. They have not yet fruited, probably because of inclement seasons.

**Ohmer—*R. villosus*.**

A variety of the long cluster type originated by Mr. Nick Ohmer of Ohio. Our plants are vigorous and produced a good yield in 1897. It is mid-season to late; berries large and of good quality.

**Rathburn—*R. villosus* x *canadensis*.**

This belongs to the loose cluster group and is supposed to be a hybrid, though it is quite upright in habit and is propagated by suckers. The plants introduced to our grounds in 1898 have not done well and have not yet fruited. Mr. Pennock, a local nurseryman and fruitgrower considers this variety by far the best of any of the many he has tested on his grounds.

**Snyder—*R. villosus*.**

This old and best known variety is of the short cluster type. It makes a large vigorous growth with us but has not yet fruited.

**Stone Hardy—*R. villosus*.**

This is a variety of the short cluster type originating in Illinois. The most enchanting sight that the writer ever saw in the blackberry line was this variety growing at Madison, Wisconsin, so marvelously loaded with fruit that the large and luscious berries could be literally gathered by the handful. How it may succeed here with sufficient water for irrigation is yet uncertain, although the plants have done well.

**Wilson Early—*R. villosus* x *canadensis*.**

This variety of the loose cluster type and of hybrid origin was discovered in New Jersey in 1854. It is propagated both by root-tips and by suckers. It is a popular variety in New Jersey, demanding close pruning to prevent over-bearing. With us the plants have done well, giving us the best yield of any variety in 1897 and being about the only one to bear perfect fruit the past season.

**Wilson Jr.—*R. villosus* x *canadensis*.**

This variety, originated by Wm. Parry in 1875, is said for all practical purposes to be identical with its parent, Wilson Early. On our grounds they appear to be quite similar, but the "Jr." does not equal the "Early" in endurance of heat and drought.



# The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

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AGRICULTURAL EXPERIMENT STATION,

UNIVERSITY OF ILLINOIS.

## BROMUS INERMIS.

—BY—

F. L. WATROUS, H. H. GRIFFIN and J. E. PAYNE.

# The Agricultural Experiment Station

FORT COLLINS, COLORADO.

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# Bromus Inermis.

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F. L. WATROUS.

Referring to this grass, Press Bulletin No. 47, Kansas Agricultural Experiment Station, makes the following statements: "Awnless brome grass or Hungarian brome grass (*Bromus inermis*) is a native of the dry, sandy regions of Europe and Western Asia. It is a perennial, about the size and somewhat the general appearance of Meadow fescue or English blue grass. It spreads by creeping underground stems or rootstocks. It has been tested by many of the experiment stations, from Canada and North Carolina to Mississippi and California. All recommended it highly for dry, sterile, light or sandy soil."

So far as known *Bromus inermis* was first grown in Colorado at the Arkansas Valley Substation in the year 1892. Out of many different varieties, it alone gave sufficient promise to encourage a second trial. In 1894 the home Station at Fort Collins began investigations as to its value, since which time several sowings have been made in a variety of soils and under widely dissimilar conditions. The grass has been grown on heavy clay with scant irrigation, on the same soil with an ample supply of water, on light soil, above irrigation and on heavy soil, approaching "gumbo," with and without artificial watering. Under all these conditions the grass has succeeded to the extent that a thick, heavy sod has been formed, producing an abundance of forage of rather coarse quality, but readily eaten by horses, sheep and cattle. It has never produced hay in sufficient amount to be considered valuable for that purpose, but sown with alfalfa it promises to be of value for horses. In quality it is believed to be equal to orchard grass, or possibly as good as timothy. It is, of course, inferior to Colorado blue stem or buffalo grass, but where successful it will make up in quantity what it lacks in quality in comparison with these two grasses.

Brome grass produces a very heavy sod, which it is extremely difficult to plow when well set. The ground, to a depth of six or eight inches, will be completely filled with a mass of matted, fine roots, so that the sod will be turned over in solid slices, and remaining of so tough a texture that an excessive amount of

preparatory cultivation is required in order to get in suitable condition to receive any other crop. The disk harrow is the only implement known which will finally subdue this sod. As to the effect on soil fertility, nothing definite is known, although a fair crop of flax was grown upon a plot of this sod ground the past season.

In Colorado *Bromus inermis* is specifically a pasture grass, and it may be truly said it is the only tame grass yet discovered which can, with any degree of success, take the place of the departing pasture grasses of the plains. The closest pasturing and severe tramping have had no effect in destroying the sod. After having been gnawed tight to the ground by sheep, it shows growth within a week after stock is removed, even in late fall when nights are frosty. In the spring brome grass affords pasture from two to three weeks earlier than any other grass known to this locality.

Many complaints are heard from various localities respecting the worthlessness of seed, all of which, thus far, has been imported from Europe. The Kansas Experiment Station reports that about ninety per cent. of this seed fails to grow. Experience at this Station last season seemed to verify this statement, though it is too early as yet to speak with precision in the matter, from the fact that brome grass comes up very much thicker the spring after sowing than would have been expected from its appearance in the fall. Whether this is due to some of the seed lying dormant, or to an extension of the root system at some time between fall and spring, has not been ascertained. The fact has been noted elsewhere, and thoroughly proven here, that it is best not to be discouraged over a seeming light stand the first season, but wait until the grass has a chance to show up the following spring before plowing it up or adopting any radical measures.

For spring sowing, brome grass should be sown early in this country if it is to be grown without irrigation. With irrigation it may be handled successfully by sowing at any time during the growing season. It requires a clean, well pulverized seed bed, such as wheat would thrive in, and should be covered from one to two inches in depth. Owing to the light, chaffy nature of the seed, we have been unable as yet to sow it evenly in an ordinary drill, though this would be the ideal way. It has been sown broadcast by hand and harrowed in. The condition of the soil is of more importance than the manner of sowing.

It would not be safe to recommend this grass for indiscriminate sowing. Farmers having portions of land above irrigation, or desiring permanent pasture on almost any kind of land that is not positively wet or boggy, would be justified in trying an acre or two. Sow fifteen to twenty pounds per acre. If successful, it produces a



good quantity of seed the second year, after which the sowing may be extended with small expense.

The grass has done well and is very useful here. There seems no reason why it should not do well elsewhere.

#### TESTS ON THE GROUNDS OF THE AGRICULTURAL COLLEGE.

On May 17th, 1894, two plats of land comprising one and a fourth acres were sown at the rate of 16 pounds to the acre. This soil was a sandy, clay loam of such a composition as to have been, in its natural state, practically sterile. Owing to its location being such as to render it very difficult to irrigate, it had been allowed to remain untilled. The land was broken up and gotten in as good condition as possible by aid of disk harrow and roller and the seed covered in fairly good shape. It was irrigated once the first season and made a very poor stand, thickening a little the following spring, and finally at the end of four seasons, made a complete stand, since then producing an abundance of foliage or pasture, but was never allowed to head until the past season, when it produced fifteen bushels of seed.

Another acre was sown on May 25th, 1896, on heavy clay soil and was treated as to irrigation in exactly the same manner as contiguous plats of alfalfa. This plat made an excellent stand from the first and made and produced a crop of seed the second season.

April 9th, 1897, a pasture mixture, composed of barley, rye, oats, sandwicke and brome grass was sown on a small plat of ground for sheep pasture. When sheep were removed, bromus was the only crop to recover. Adjoining this plat, the following spring *Bromus inermis* was sown on about one acre of ground. It was endeavored to sow the seed with an ordinary grain drill. Various substances, as bran and dry soil, were mixed with the brome grass seed to give it sufficient weight to feed through the drill. It was found to be impracticable and the drill was discarded. After sowing, furrows were made about this plat so that one-fourth of the plat would not be watered when the rest was irrigated. The stand on this part was never quite so good as on the balance of the plat, though it was so good that a casual observer would not notice the difference. This lot has been pastured for three years with sheep. As there was always more sheep than the pasture would support, the grass was eaten close to the ground several times each year, i. e., when it was eaten so close that there seemed to be nothing left, the sheep were removed and when water was to be had it was turned on this pasture plat. In every instance the grass came up quickly and when a few inches high sheep were turned on again.

This same season another acre plat was sown for pasture. This soil was very heavy clay, probably as near an approach to regular "gumbo" as could be readily found in this vicinity. An excessive amount of work was necessary in order to get this land in shape for seeding. This however was accomplished and an excellent stand was the result. It was irrigated the first two seasons.

The first season after sowing, the grass having a good start in May, six ewes and their half grown lambs were turned on for pasture. It supported this number for about six weeks, when the grass being eaten down very close, the sheep were kept off and fed for a couple of weeks, in which time the grass recuperated and the sheep were turned on again. This plan was repeated twice more during the season, and in October the ground seemed as bare and nearly as hard as an ordinary road bed. The following spring, however, the brome grass made its appearance in March and with the same treatment each year is still thriving and furnishing as much pasture, to all appearance, as at first.

May first, 1899, two acres adjoining the above plat were sown. The ground had been covered during the winter with a very thick coat of coarse manure, so thick was it in fact that owing to the gumbo quality of the land and its persistent sticking to the plow, only about half the manure was covered up, the rest sticking out and producing a very unfavorable condition of seed bed. The seed was sown however, and covered as well as might be. This land became very dry and it was not thought possible that any of the seed could germinate. After all the other crops on the farm had been irrigated there came an opportunity to run the water on this piece, which was done. At the end of that season a few spears of brome grass were visible, but they were so few that it was thought the plat was

an entire failure. Upon examination early in the following April however, so much improvement was noted that it was thought best to let the land alone, at least for one season, and note the result. By June first there was almost a complete stand of grass, so that sheep were pastured there the balance of the season till October, when the sheep being removed, the grass started up again during the warm days and frosty nights of October and November, showing a thicker stand than could be seen in the middle of summer.

Late in May of 1900, about 14 acres of raw, unproductive land was sown to brome grass at the rate of about 15 pounds to the acre. Considering the quality of the land, the lateness of the season, and the pressure of other work, this undertaking was very ill advised, and would seem to have promised nothing but failure from the first. However about half a stand was secured over a good portion of the land, and the coming spring will show what may be expected of this grass under the very worst conditions.

In the spring of 1898 an experiment was tried on a neighboring farm, of sowing bromus on a high knoll, above reach of irrigation. This soil was a good quality of sandy loam, and having never been irrigated is better calculated to receive and hold falling moisture than would soil which had been irrigated. A fairly good stand was secured here and it has gradually thickened since, producing good pasture, and has been particularly noticed each spring as producing green pasturage at least two weeks before alfalfa or any other grass.

April 9th, 1898, in a small field thickly sown with alfalfa, a strip 8 feet wide the length of the field was sown with *Bromus inermis* seed. Under ordinary treatment for alfalfa, this strip grew well, was cut three times each year and is still engaged in a struggle for supremacy with the king of the Colorado field. As both were thickly sown, neither crop is at its best, which would indicate that thinner sowing would be advisable where both are sown together.

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## **Trials at the Arkansas Valley Substation.**

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H. H. GRIFFIN, Superintendent.

April 22, 1892, a plat 145 feet long, 67 feet wide, was sown to seed of *Bromus inermis*. An excellent stand was secured, and the records report it growing ten inches tall and producing seed. In 1894 this plat was harvested July 12th, and from the product 208 pounds of cleaned seed was secured. By this time the sod had become very close, and most of the growth made was around the edges of the plat. Wherever it was sub-irrigated the growth was from one to two feet high, but wherever flooded it became sod bound and made almost no growth.

This was about the manner of its growth the succeeding years, until the present Superintendent took charge, in March, 1898. Noting that it was making a very poor showing, a portion was given a dressing of gypsum, and a sharp implement in the nature of a sub-soil plow was run through the other portion to cut up the sod, thinking it might do better were it relieved of the sodded condition. Neither remedy proved to be of any benefit. The only growth of any importance was the narrow fringe around the edges, or on the ditch banks, where it secured sub-irrigation. It does not



seem to withstand flooding. Becoming satisfied that no returns were to be secured by further allowing this to stand, it was plowed up in the fall of 1898. The sod was extremely compact, and much of the season of 1899 passed before it was rotted.

To a field of three acres that had been sown to rye in October, 1894, was added *Bromus* seed on April 9th, 1895, at the rate of twenty-six pounds per acre. The seed was harrowed in, and germination secured by irrigation. A fairly good stand was secured over the greater portion of the field. In 1896-97 it furnished some pasture during a portion of each year. In 1898, when first taking charge of the Station, it was noted that this grass started to grow very early in the spring. It made some growth until about the middle of May, when all development stopped. It remained in about this condition until fall rains occurred, when it made some further growth, but not enough to warrant giving it much consideration. It was also noted that where an application of barnyard manure was given, that the growth was increased considerably. It was further noted that while the grass would withstand considerable drouth without dying out, yet to secure any growth or vigor of plant a considerable amount of moisture was necessary, and this moisture should preferably be in the form of rain. Nine irrigations were given this field in 1897, between March 26th and October 1st. As before stated, where flooded it soon became sod bound. As the returns from this field did not warrant retaining it any longer, it was plowed up in May, 1899, and seeded to corn.

That this grass did not improve the fertility of the soil was apparent from comparisons of adjoining fields, both in 1899 with corn and in 1900 with oats. An adjoining field that had been in red clover, and plowed up at the same time of the *Bromus*, gave fully fifty per cent. greater yield in the two crops above mentioned.

Not being satisfied that the trials had been conclusive with this grass, and thinking that perhaps fall sowing would be of benefit in securing more favorable results, a field of one and one half acres was prepared, which was seeded with seventy pounds of *Bromus* seed, September 7, 1898. This land was irrigated by means of furrows two and one half feet apart through the land, in which the water was run, giving it sub-irrigation as much as possible. A splendid stand was secured, and the grass was up well before winter set in. It was given the best of attention in 1899, and the heavy rains of the summer and fall were conducive to its best development. The results of the year were promising, and it appeared as though this grass, under such conditions, would prove a valuable adjunct to the agriculture of this section. It was pastured but slightly in the fall of 1899, and by the 20th of April, 1900, furnished quite good pasture. One dairy cow was turned upon this lot and pastured for about six weeks. While there seemed to be a

plenty of forage. the cow did poorly. She lost in milk and flesh, so much so that it was necessary to seek some further food to secure good results. Early in May this grass began to fail, and from that time to date of this writing (December 28th) has only lived, making no growth whatever.

The season has been very hot and dry, and under such conditions, which often prevail, the artificial application of water does not seem to be the requisite to produce growth and vigor of plant. Its behavior here tends to show that it is better adapted to a region of lower mean temperature and greater summer precipitation, and that the soil should contain much more clay—what would be termed a stronger soil. It becomes sod bound under irrigated conditions, and soon fails to produce growth of any value. The grass is coarse and very low in nutritive qualities. I see but one place where it may profitably be employed, and that is as a soil retainer on the banks of ditches that are liable to wash. The fact that it thrives where the water is applied in this way, and that it forms such a dense sod, would warrant its use in cases such as above mentioned.

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## **Trials at the Plains Substation.**

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J. E. PAYNE, Superintendent.

1895. A plat was sown March 22nd on well prepared ground, which was broken in 1894 and thoroughly plowed in March, 1895. This seeding was blown out by spring winds. Later in 1895—June 6th—the same plat was sown to *Bromus inermis*. A good stand was obtained, but grasshoppers destroyed it all.

1896. Seed from an unknown source was used to sow a plat to *Bromus inermis*. The ground was well prepared, and had been cultivated in 1894 and 1895. None grew. The plat was seeded May 2nd.

1897. A plat was sown May 2nd, on well-prepared ground which had been in sorghum in 1894, 1895 and 1896. No stand was obtained—in fact no grass was seen to have grown from this planting. Seed: The same as that used in 1896. It was of unknown origin, but was bought from a reliable seed house.

1898. A two-acre plat was sown on land which had been well cultivated in sorghum and corn during the four years 1894, 1895, 1896 and 1897. Seed furnished by the Department of Agriculture was used. This seed was imported from Russia. A good stand came up, and the grass promised well until late in the



summer, when the dry weather killed much of it which grew on the higher part of the plat. The grass remained green until late in the fall, and stood the winter well. It started in the spring of 1899, about the same time that the Colorado bluestem (*Agropyrum* sp.) started, but the dry weather in the summer destroyed nearly all except that which was in a low place, where extra water collected. This patch threw up a few seed-stalks twelve inches high. The spring of 1900, more especially April, was very wet. The remaining grass thickened and completely occupied the ground where it had secured a foothold (this was confined to about ten square rods which got the benefit of storm-water from the prairie). The seed-stalks grew twelve to twenty inches high, but they were thin on the ground. The main, leafy parts of the plants were too low to be cut by the mower.

1899. Seed sent out by the U. S. Department of Agriculture in 1898 was used to sow a plat on ground which had been cultivated in hoed crops since 1894, with the exception of one year, when it was in barley. Only a few plants appeared, and these died during the dry weather of the summer. This plat was sown April 20th.

1900. Fresh seed, grown in Manitoba, was furnished by the U. S. Department of Agriculture for seeding a plat this year. It was sown on well-prepared ground, which had been cultivated in hoed crops every year except one since and beginning with 1894. Only a few plants appeared, and these died during the summer. This plat was sown April 23d.

NOTE 1.—“Well-prepared ground” means that the land was plowed from five to eight inches deep and thoroughly harrowed until the seed-bed was practically free from clods. In 1898 and 1899 the land was plowed eight inches deep and packed with a sub-surface packer.

NOTE 2.—The choice land of the Farm was used every year except 1898, when a two-acre piece, which represented the wettest and the driest land on the Farm, was chosen.

NOTE 3.—Seed. The seed used in 1895 and 1898 proved to be good by growing. The seed used in 1896 and 1897 may not have been good, as its origin was unknown. The seed used in 1899 was some which was left from the supply sent by the U. S. Department of Agriculture in 1898. The seed used in 1900 was fresh seed obtained from the Department of Agriculture, which was grown in Manitoba. Also some of the old supply sent by the Department of Agriculture in 1898 was sown. Both these gave about the same number of plants.

NOTE 4.—All seed was sown broadcast and harrowed in with a smoothing harrow.

## BROMUS INERMIS SEEN ELSEWHERE ON THE PLAINS.

Only one plat was seen growing. That was on the ranch of Robt. Lucore in the northern part of Lincoln county. I saw this plat in May, 1900. It then showed scattered bunches among the weeds. The grass appeared to be growing well, but was a very poor stand. It was a small plat. Mr. Lucore said that he thought *Bromus inermis* a good grass for his neighborhood, but he did not care to plant any more, even if the seed was furnished him free.

## WEATHER AND COMPARATIVE CONDITIONS.

During the six years *Bromus inermis* has been tried here, the rainfall has been as heavy as usual. Native hay has been cut on the uplands every year, except 1900. No year of the six under consideration was as drouthy as were 1893 and 1894.

## GENERAL COMMENTS.

1. In common with all so-called drouth-resistant plants, the testing of *Bromus inermis* has proved to be very unsatisfactory here. The failure to get a stand of plants is the greatest difficulty experienced. If rain does not fall at the right time after seeding, we are almost sure to fail to get a stand which will be fair to the plant under consideration. If a stand is obtained, continued drouth before the young plants are strong enough to resist it, may destroy all hope of successful termination of the trial.

2. While we feel that the grass (*Bromus inermis*) is a failure under the conditions existing here, we realize that it might succeed where conditions are not quite so unfavorable. A difference in the distribution of the rainfall might bring success where we have to record failure.

Our experience and observation compels us to recommend to those who think of trying *Bromus inermis* on unirrigated land in eastern Colorado, that they test it on a small scale for a few years, before plowing up buffalo grass to make room for it.



# The Agricultural Experiment Station

OF THE  
AGRICULTURAL EXPERIMENT STATION  
Agricultural College of Colorado.

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UNIVERSITY OF ILLINOIS.

## CANTALOUPE.

—BY—

H. H. GRIFFIN.

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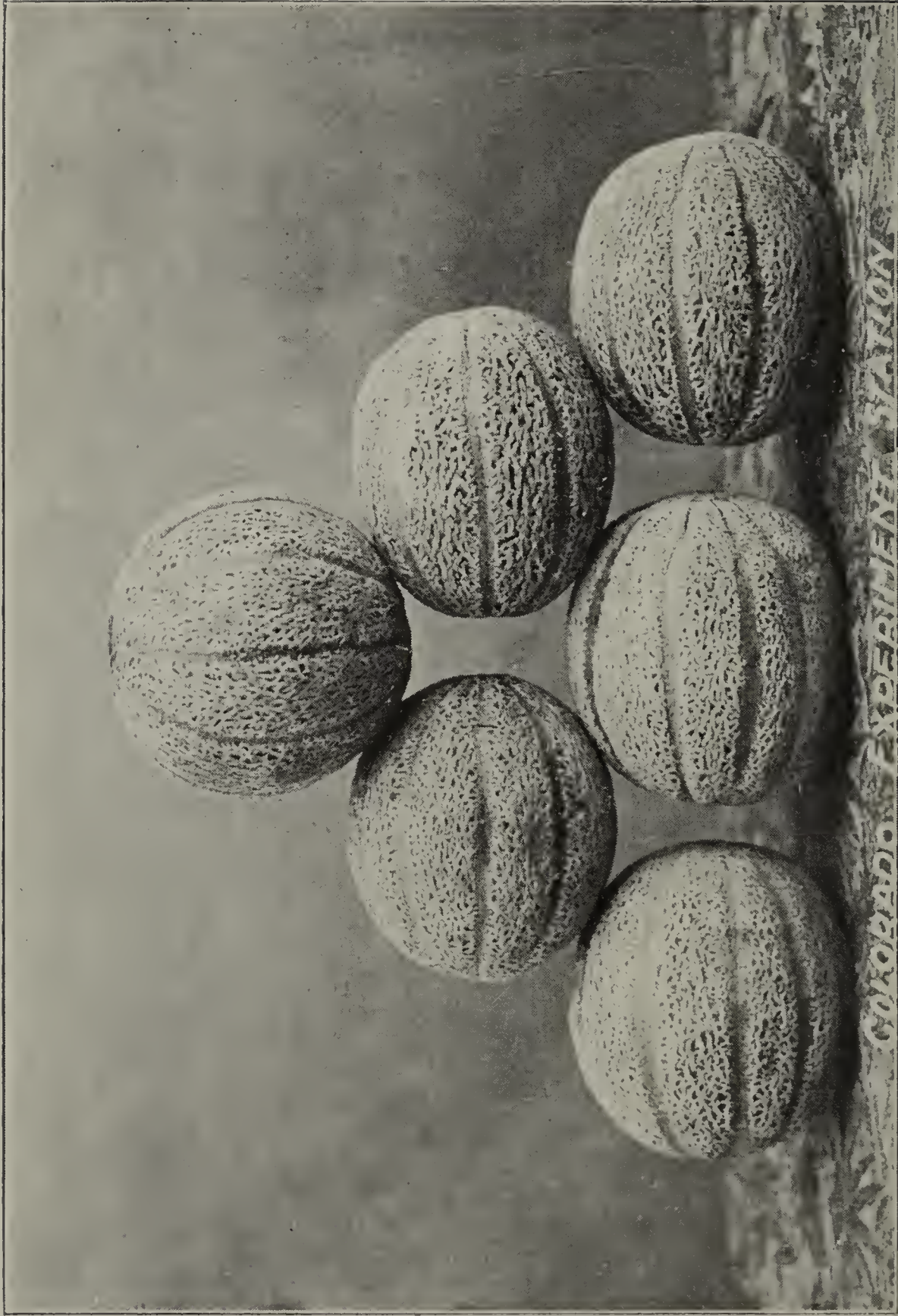
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"NETTED GEM" Cantaloupes, grown at Rockyford, Colo.



# THE CANTALOUPE.

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BY H. H. GRIFFIN.

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## INTRODUCTION.

The Arkansas Valley of Colorado has for some years been famous for its cantaloupes.

During the season of 1900, 780 cars were shipped, which represents the product from about 2,500 acres.

The cantaloupe is known as the "Rocky Ford" from the town that has led in the industry. The variety grown is the Netted Gem, which Burpee claims to have the distinction of originating. Through environment it has become so perfected in the vicinity of Rocky Ford as to be unsurpassed in quality, and needs only to be introduced in any market to at once take possession of it.

The melon plant is of rank growth and succulent tissue. It thrives best under conditions of high temperature, dry air, and continuous sunshine, and a deep, warm, sandy loam soil. It is as delicate in constitution as in texture. It does not adapt itself readily to varying conditions nor to sudden climatic changes, and its tissue offers little resistance to the attacks of fungi.

## CULTIVATION.

Were it not that there are many amateurs growing this crop, owing to the rapid settling of the lands in the Arkansas valley of Colorado, this bulletin need not deal with this phase of the subject.

The first planting is done from the first to the tenth of May; seldom any advantage is gained by putting the seed in earlier than May 1st. The land is put in good condition by rather deep plowing, harrowing and leveling. Furrows are then run with a shovel plow from 6 to 7 feet apart and the seed planted by the side of the furrow, making the hills from 5 to 6 feet apart in the rows. Uniformity of planting facilitates cultivation, as for a considerable time the field may be cultivated in both directions. Care must be exercised not to plant the seed too deep. The depth should not exceed one inch.

Some growers irrigate the furrows and plant afterwards, while others plant and then irrigate, permitting the water to reach the seed by percolation. I prefer subirrigation to

germinate the seed, as the soil is apt to become crusted and dry if it is handled and pressed after irrigation.

Plenty of seed should be used—from 10 to 15 seeds to each hill—and when the plants have put forth four leaves, thin to three plants for each hill. Cultivate and hoe sufficiently to secure good tilth until the vines run well, or are from two to three feet across the hill. Then the irrigating furrows should be run and cultivation cease, giving such hoeing as will keep down weeds.

#### SEED.

Good seed is a prime requisite for success with the cantaloupe, but not enough attention has been paid to the selection of it. Few have made any systematic selection of seed, looking well to the shape, size, solidity, depth of flesh, seed cavity, color of flesh and quality. Many have bought from dealers who knew little of the quality of seed sold, and the result is that many melons sold as "Rocky Ford" are not up to the standard. The effect of poor seed is more apparent in those districts in which there are many amateur growers, than where the older growers predominate.

A pure Rocky Ford cantaloupe when ripe should have a silver colored netting which is lace-like in appearance. The skin should be green turning to a peculiar gray color when the melon is fit for shipping. The flesh should be green in color and so sweet and luscious that it may be eaten close to the rind. The melon should have a small seed cavity and the portion of the flesh immediately surrounding it be slightly tinged with yellow. The melon should weigh about one and one-half pounds and be very solid and firm.

The cantaloupe growers should save seed from the very best melons, for in this way only can the quality be maintained or improved. No grower should save seed for his planting without testing the quality of the melon. Occasionally a melon may be perfect in appearance, but not of first rate quality.

#### HARVESTING.

Much seed is shipped to points outside the state and the product from this seed is shipped to market as "Rocky Ford" melons. "Rocky Ford" melons, so called, are on the market about the time the melon is setting on the vines in the Arkansas valley. A few melons are shipped the first week in August, but heavy shipments do not commence before the middle of the month. The melons are picked into sacks, carried over the shoulders of the pickers, and are at



once taken to the shade—packing sheds being made for the purpose—where they are crated. The standard crate holds forty-five perfect melons, in three tiers of fifteen melons each, and weighs about sixty-nine pounds. There are also used, to some extent, the two-layer crate, which is two-thirds the size of the standard, and the “pony” crate holding forty-five melons, but smaller than those of standard size. The standard crate is (inside measurement) 22 inches long, 12 inches wide and 13 inches deep.

When it is proper time to pick for shipment, the stem slightly parts from the melon. No stem tissue should adhere to the melon, but there should be a smooth surface where the stem was attached. The netting and skin has a peculiar grayish appearance, which is easily distinguished when one becomes accustomed to picking.

The cantaloupe is very perishable and rapid transportation, in refrigerator cars, is required. By this means melons of good quality are placed in all of the markets of the eastern states. The shipping period (from the same vines) should extend over not less than thirty days; a more rapid ripening than this is generally indicative of unhealthy conditions. As high as 300 crates per acre have been taken from alfalfa sod, but 100 to 150 crates of marketable melons per acre is considered a good yield.

#### IRRIGATION.

The essential thing in irrigating is to keep the water confined to the furrow, reaching the roots only by percolation. This keeps the soil in good condition, does not cover the vines with mud, and leaves the fruit in dry condition. If the water stands on the fruit it is apt to induce decay or cause uncolored or soft spots, which make the product unsalable. It is common to irrigate every ten days, paying little attention to the needs of the plant. The tendency is to irrigate too often early in the season.

The most water is required about the time the blossoms commence to set well, previous to this giving only enough to keep the plant growing well. When the plant commences to bloom profusely, irrigate thoroughly and afterwards give only so much water as will keep the plant in good thrifty condition. A too moist condition is apt to increase the spread of any fungus trouble.

In 1899 three plats were used to test the effect of irrigation on quality and production. One plat had seven irrigations, June 19, 30, July 10, August 1, 17, 26, and Sep-

tember 4; another three irrigations, June 30, August 1, and September 4; and a third plat one irrigation, July 10. Heavy rains occurred in July, and considerable rain fell in August.

The plat irrigated but once did not yield so heavily as the others; the vines and fruit were smaller, but the fruit was of better quality. The plats numbered one and two yielded about the same, and as far as could be judged, the quality was the same. Evidently, plat No. 1 received twice as much water as was necessary.

#### FERTILIZERS.

Virgin soils produce good melons both in quality and quantity, but fertilization is soon a necessity. Since fungus troubles have become annoying, it is not advisable to apply any heating manure to the soil just previous to growing cantaloupes, as it has a tendency to increase the trouble.

A comparative trial in 1899 with melons grown on alfalfa sod, on cropped land manured with well rotted barnyard manure in the hill, and on cropped land fertilized with bone dust in the hill, showed the best results from the alfalfa. The product was nearly doubled, the quality was better, and the ability to resist fungus troubles greater. Alfalfa sod brings maximum returns, and in turn the melon easily subdues the alfalfa and puts the land in splendid condition for succeeding crops.

#### TRANSPLANTING.

A test was made in 1899 to note to what extent hot bed propagation may hasten maturity and how successfully it may be performed. The seed was put in the hot beds April 3. Some of the seed was put in cans, so arranged that the plants could be taken from them without disturbing the roots, while others were put in the bed without any support. It was found quite difficult to transplant them when the roots were at all disturbed. Fully 95 per cent of those set from the cans grew, while only about 50 per cent of those taken from the bed without support survived. May 8, the first plants were taken from the bed and set in the open field. The first seed planting in the open field was April 29 and the second May 10.

The first ripe melon was taken from the transplanted vines August 17, only one day earlier than melons grown on ground fertilized with alfalfa or manure, and only four days earlier than those grown without any fertilizer.



However, they ripened (in quantity) faster, and for the next ten days gave more ripe melons than any other planting.

#### DISEASE OF THE VINE.

Until recently the industry has advanced at a rapid pace, no disease or insect pest causing trouble of any consequence.

A blight or rust first attracted attention in a few fields in 1896, and there was a slight increase in its spread in 1897. No one gave it serious thought at first, and it was not until it became prevalent and the damage serious, that anyone realized to what extent it might cripple the industry. My attention was first called to it in 1898, when it became so prevalent in some fields as to do much injury to the crop at about the time the melons were ripe.

It first appeared in well defined centers on fields that had been cropped with melons continuously for some years. In 1899 it was apparent that the disease diminished as we receded from these centers, and, in most cases, it did not appear on the remote fields until later in the season.

The leaves were found to be covered with numerous brown spots, giving them a rusty appearance. The spots ran together, eventually killing the leaf. The stem was also covered with spots, and in some cases the melon was affected, the diseased tissue often extending to the heart of the melon.

Leaves and stems were sent to Prof. Crandall, who pronounced the trouble due to a fungus (*macrosporium*), but sent the specimens to Ellis and Everhart, who pronounced it a new species, naming it "*cucumerium*."

To the casual observer, the cantaloupe blight, which is caused by a true parasitic fungus, first appears as a number of brown spots about the size of a pin head upon the leaves in the center of the hill. A careful examination of the younger leaves shows where the fungus has been at work, sometime before it is apparent by the brown appearance. It can be seen where the leaf tissue has been eaten away, and when the injured tissue dies, then it is that the brown appearance occurs. These spots gradually enlarge until they may attain a diameter of half an inch, and the number sufficient to envelop the leaf and cause its death. In some badly affected fields can be seen spots of all gradations in size, from those just forming on the young leaves to those so large as to destroy the older leaf.

During nearly the whole season the cantaloupe is putting forth new growth that is very succulent, and this

parasite may be doing incalculable injury long before the grower is aware of its presence. This is especially true if the weather conditions are moist and favorable to its increase and spread.

#### EXPERIMENTENTS IN 1899 FOR THE CONTROL OF THE DISEASE.

Observing in 1898 that the disease was apparent only on certain fields, I made a collection of seed from these for planting the following year, to see if it was communicated by the seed. This seed was planted in the spring of 1899 away from other melons for the purpose above mentioned, and for some preliminary spray work for the control of the disease.

Three rows, each 250 feet long, were planted, the middle one being reserved for spraying with the Bordeaux mixture, using the others as checks. The row was sprayed June 22, and again June 30, with Bordeaux mixture—4 pounds of copper sulphate (blue stone) to 40 gallons of water. At this time there was something on the vines that looked like blight. The next spraying was done the 22d of July, at which time the blight was in evidence and spreading rapidly. The row was again sprayed July 31 and August 11.

The weather previous to June 19 had been very dry. Subsequent observations have shown that the spread of the disease, previous to this time, would not have been rapid enough to be discerned, even if the weather had been moist.

After June 20, rain and dews were plentiful; seven inches of rain fell during July, 5.14 inches of this in the week commencing July 14. The vines were completely submerged and the spray, no doubt, mostly destroyed. The weather conditions following were very favorable to the spread of the disease.

Owing to the weather conditions during July, it was not apparent that any benefit was secured from the two early sprayings, but a decided benefit was obtained from those made after July 22.

The sprayed vines remained green and in a growing condition long after the others had succumbed to the disease, and fruit of good quality was picked from them the first week in September. Two weeks previous to this the last merchantable melons were taken from the unsprayed vines and they, at all times, were inferior in quality to those picked from the sprayed vines. They ripened prematurely and the taste was insipid; this alone being sufficient



guide to determine from which vines the melons came. It could not be said that the infection came from the seed, for these vines were no worse infected with the blight than other melons on the station property or in the adjacent country. Some of the seed was held over for planting in 1900, and the results are like those mentioned.

All of the fields in the vicinity of Rocky Ford were more or less affected with the disease, the spread being much more rapid than anyone anticipated. This caused us to inaugurate experimental work, late in the season, for its control.

There were, at the station, seven rows of cantaloupes, each 275 feet long, on alfalfa sod. One of these was sprayed with the Bordeaux mixture July 31, and again August 11. This work confirmed the results enumerated above.

Another row was sprayed with the ammoniacal copper carbonate solution (1 oz. to 6 gallons of water) August 4, and again August 8 and 11. Some benefit was secured from this spray, in the same way it was with the Bordeaux mixture, but it was not so pronounced, nor does the spray adhere so well to the plant.

Mr. I. D. Hale had some June planted melons which we secured for experimental purposes. They were sprayed with the Bordeaux mixture July 27, and again July 31 and August 11.

About one-eighth of an acre of melons was sprayed for G. W. Swink, August 15 and 16. Owing to press of work only one application was given these vines, but the benefit from the spray was quite marked when compared with the remainder of the field.

August 21 we sprayed about one acre of late melons at I. D. Hale's, in which the blight was very bad; it appeared as though no returns could be secured from the field. Even after the vines were thus affected there was a marked improvement in the appearance of the vines, and the fruit did not deteriorate in quality nearly so rapidly as in an unsprayed portion of the field.

Mr. C. S. Fenlason had about  $1\frac{3}{4}$  acres of late melons which were secured to spray, to verify previous results and to further study the cost of the work. The vines were very large, completely covering the ground.

A barrel of spray mixture was put in a slip scraper which was pulled backwards, and two rows taken on each side. The work was done August 22 and 23. Twenty-two pounds of copper sulphate were used to make

the spray. It required three men and one horse thirteen hours (together with a boy about two hours to turn the vines) to complete the work. The cost was estimated at \$6.75 per acre.

Three hundred crates of good melons were sold from the field. Mr. Fenlason thinks the spray saved the crop from destruction. A few vines in this field were not sprayed and the advance of the disease on these was very noticeable. An adjoining field of melons so succumbed to the disease as to be of little value. The results of the year were of one accord; confirming the benefits from the spray as above mentioned.

#### EXPERIMENTS OF 1900.

The cantaloupe season was very dry and hot, and hence extremely favorable to the vine and unfavorable to the spread of the disease, so that the results have not been so marked as was the case in 1899, when rain was prevalent.

May 8 about six-sevenths of an acre of alfalfa sod was planted to cantaloupes, it being the intention to spray portions of it at stated intervals for the purpose of testing what number of sprayings would be the most efficient. June 11 the blight seemed to be making its appearance and the vines as yet not running. The same appearance was also found in other fields. June 13 the most of this patch was sprayed with Bordeaux mixture, July 11 sprayed the second time, and July 31 a portion of them sprayed for the third time.

The weather continued extremely dry and hot during July and August, and in but few places was there any rapid spread of the disease. There was no appreciable benefit from the third spraying.

Comparing the sprayed vines with checks and with adjoining unsprayed fields, there was an appreciable difference in the appearance of the vines, in the quality of the fruit, and the manner in which it ripened. During the last of August, the fruit on the sprayed vines was ripening slowly, while the unsprayed vines were giving up their fruit rapidly.

About four acres of melons, belonging to leasers on the station, were used for experimental purposes. Two acres of this field were sprayed June 14 while the vines were quite small, but few of them running. A second spraying was given them from July 7 to 12, at which time they were running considerable.



A third acre was sprayed July 28 for the first time, which was done for the purpose of noting the effect of late spraying. The blight was showing considerably in the center of the hills, but not spreading to any appreciable extent. After this spraying there was a peculiar appearance of the edges of the leaf (which to some might be alarming). Much of the portion assuming this appearance was brown at the time of spraying, but the centers remained green and the leaves retained their vitality, which was not the case with those unsprayed. This appearance of the edge of the leaf did not occur with those sprayed early, and its appearance is something for which I am not able to account. The remaining acre was not sprayed, for the purpose of a check upon the work.

The most noticeable feature to the parties picking the product from the field was the rapidity with which the unsprayed portion ripened its fruit. Soon after harvesting commenced the yield on this acre was twice as great as on an equal area of sprayed vines, and the quality was not so good. The melons were ripe and picked on this acre fully two weeks before they were on the other three acres. Those having the field in charge were in doubt, when the work commenced, whether there was any efficacy in the spray, but the ripening of the fruit dispelled any such doubt. There was an appreciable difference in the appearance of the vines, and this was discernable for some distance. People who saw the vines early in September would remark as to their health and vigor, and they continued to bear until frost.

Owing to the continued dry weather, the two early sprayings seemed to be all that was required, and were preferable to the one spraying done later. Had moist conditions arisen, it is probable that one or two more sprayings would have been necessary. However, the results from the late work gave evidence that good results can be secured from the late applications.

What has been said is further substantiated by results in other fields near by, in which the vines and crop were, at one time, more promising, but (due to the diseased conditions) ripened their fruit too rapidly, unevenly, and the quality was undesirable. On these fields the spread of the disease from day to day was apparent during the latter part of August and the first week of September.

An ordinary field of cantaloupes should not yield, during the height of the season, more than twelve crates of

marketable melons per acre per day, but on some diseased fields it was not uncommon for more than twice that amount to be taken.

As a further test of the efficacy of the Bordeaux spray, four acres were sprayed in the field belonging to John Deweese. The first application was made June 18, and the second July 7, it being the intention to give a third, but press of work prevented it. One row was left through the center as a check, and the results showed a decided benefit to the vines and the ripening of the fruit. This was especially marked when comparison was made with an adjoining field that was planted later, but which matured its fruit earlier, owing to the disease.

Mr. Deweese feels that the spraying saved a considerable part of his crop. His greatest yield from the four acres did not exceed 50 crates per day, in a total yield of about 600 crates. When the season was nearly closed and the vines had been tramped and injured, the benefit, from the appearance of the leaves, was still apparent.

I had under observation four fields, in which spraying had been done by farmers who were incited to do the work by the results of the previous year. Some were highly pleased with the results, and in no case was there a failure to derive some benefit.

I wish to emphasize what has been said in regard to the benefit on the quality of the fruit—the value of the spray is not by any means to the vines alone. It keeps the vine in better health, and the necessary vitality is secured for the proper development of the fruit.

#### COST OF SPRAYING.

A record of expense on the field of John Deweese for labor and material is as follows: June 18, 4 hours with 3 men, 1 team and  $1\frac{1}{2}$  barrels of spray mixture. July 7, 9 hours with 3 men, 1 team and  $3\frac{1}{2}$  barrels of spray mixture. An estimated total of \$9.80 for two sprayings on the four acres.

The cost of spraying the two acres on the station, twice, is as follows: June 14,  $1\frac{1}{2}$  hours with 3 men, 1 team and 1 barrel of spray mixture. July 7 to 12,  $2\frac{3}{4}$  hours with 3 men, 1 team and  $1\frac{1}{3}$  barrels of spray. The acre sprayed July 28 required 3 hours with 3 men, 1 team and  $1\frac{1}{2}$  barrels of spray, together with 1 hour for 1 man to turn the vines. This makes an average cost of \$4.47 for spraying an acre three times. The vines varied in size from those just running to vines from 3 to 4 feet across.



These estimates, together with those for 1899 at Mr. Fenlason's, cover the cost at all stages of the melon's growth, and from this one can tell approximately what the cost will be, taking into consideration the size of the vines. The price of copper sulphate (blue stone) is assumed to be ten cents per pound in these estimates.

Our appliance for doing the work in 1900 was a platform arranged on two wheels of a grain drill, upon which was a barrel containing a spray pump. Two lengths of hose were attached to the pump, sufficient to cover from 4 to 6 rows at a time, depending upon their size. The double-trees were spread to correspond with the width of the wheels and allowed the team and cart to spread over one row.

#### ACTION OF THE FUNGICIDE.

The object in applying the fungicide is to destroy the fungus without injuring the plant tissue. Further infection will be prevented and the tissue that the parasite would otherwise appropriate will be left to perform the functions of the plant.

The Bordeaux mixture is a combination of copper sulphate (blue stone), lime and water. The lime unites with the sulphuric acid, forming gypsum, and the copper is left in an insoluble condition which the gypsum tends to cement to the leaf. The carbonic acid of the air and the ammonia of the rain and dew dissolve slight amounts of the copper. It is very essential, when preparing this mixture, to use plenty of lime—an excess will do no harm. Experiments have shown that when an excess is used the copper is slower dissolved and, consequently, held on the plant longer. There are a number of ways the copper may act upon the fungus.

The spores may be prevented from germinating by inhibitory action; the spores may be killed outright before germination has commenced; the germ may be so weakened as to be unable to enter the host plant; or the presence of the copper on the leaf may impede the fruiting of the fungus already within the tissue of the plant. I believe the efficacy of the spray is due to the destruction of a considerable portion of the fungus growth present and to the prevention of the germination of the spores upon the new tissue. That the spray quickly prevents the enlargement of the spots is plainly to be seen.

The spores of the fungus, no doubt, germinate, grow and produce spores in a few days, but this period of growth may be hastened or greatly retarded by the weather con-

ditions that prevail, and for this reason the results may vary, according as one is fortunate in applying the spray at just the time when it may be most destructive to the fungus. The development of spores apparently takes place faster in late than in early season, which, no doubt, accounts for the greater rapidity of its spread later in the season.

#### EFFECT OF WEATHER CONDITIONS.

The season of 1899, being alternately wet and dry, afforded an opportunity to study the effect of weather upon the development of the fungus. When moist conditions prevailed, its spread was so rapid that it was plainly apparent, but dry weather at once checked it.

The number of sprayings required, and the time at which the spraying should be done, will have to be regulated largely by the weather conditions. When it is remembered that there may be, under favorable conditions, many successive crops (so to speak) of the fungus, and that moist, humid conditions are the most favorable for its growth, the grower will have to be guided by the weather in choosing the time for making the application.

The grower is mostly interested in preserving the leaves in the center of the hill, and for the purpose of doing this we think it well to give one or two sprayings about the time the vines commence running. The leaves in the center of the hill give protection to the major portion of the marketable melons.

The season of 1900 was extremely dry and may be considered as unfavorable for the blight as any season could be, and yet the disease was prevalent. While it did not develop to such a degree as to greatly impair the quality of the fruit in the majority of fields, yet in most instances there was more or less injury. In some fields the shipping season was shortened fully one-half, and the product was of inferior quality.

It is far preferable that weather conditions should keep the disease under control every year, but as the disease was prevalent in 1900, the farmer must expect to be obliged to cope with it under the weather conditions that usually prevail.

The farmer must not think, from what has been said in the preceding pages, that perfect immunity is secured by the use of the spray. All that can be hoped for is such control of the disease that melons of good quality may be secured, and the shipping season prolonged to near the



same period that it would be if perfectly healthy conditions prevailed.

The subject is not exhausted in this report, but we have done enough work to warrant giving information to the farmer, that he may be able to cope with the trouble to the fullest extent that our knowledge, at present, will enable him to do.

#### PREVALENCE OF THE BLIGHT.

No evidence could be secured in 1899 that the disease occurred in any other locality than that of Rocky Ford. In 1900 I found it in all parts of the valley, with the possible exception of Pueblo. Many farmers are yet totally ignorant of its appearance, especially when it is not present in sufficient quantity to cause any rapid deterioration of the crop. A farmer, whose field was badly infested with lice and blight, cited the fact that he had shipped 200 crates per acre from the field. Inquiry revealed the fact that the shipping period had not extended over more than two weeks, and that many melons of inferior quality had been taken because, just at that time, the supply of melons was not equal to the demands of the market.

#### INJURY TO BEES.

Many hives of bees stood near one of the fields treated. The apiarist found no dead bees, nor could it be seen that any harm resulted to the bees. The blossoms of the melons live only three or four days, so that no great number of sprayed blossoms are on the plant at any one time. Most of the flowers are well protected by the leaves, so that but little of the spray reaches the center of the flower.

#### FORMULA FOR MAKING THE SPRAY.

Dissolve 4 lbs. of copper sulphate (blue stone).

Slake 4 lbs. of fresh lime.

When the lime has become cool drain off the milk, adding it to the copper sulphate solution; then dilute with water until there are 40 gallons of the mixture. These proportions we have found to be about right, but care must be exercised to use plenty of lime, or otherwise the acid will burn the foliage. It is better to err on the part of too much lime than not enough. A stronger solution can be used with impunity, but we have found as good results from this as from the stronger.

## POLLINATION.

The number of flowers born by a single melon vine is something astonishing. This is no less striking than the disparity existing between the male and female flowers. An account was kept on six vines from June 27, the time of blooming, until July 13, at which time the vines had become so interlapped that individual vines could not be distinguished.

The table shows the dates on which the flowers were counted and the number of flowers that had formed at each time. The total number of male flowers formed was 3,075 and the number of female was 253; an average to each hill of 512 male and 42 female flowers to July 13:

| Date.   | No. of Male<br>Flowers. | No. of Female<br>Flowers. |
|---------|-------------------------|---------------------------|
| June 27 | 203                     | 1                         |
| June 30 | 338                     | 11                        |
| July 3  | 474                     | 28                        |
| July 7  | 755                     | 95                        |
| July 10 | 660                     | 87                        |
| July 13 | 645                     | 31                        |

It must be remembered that the vines continue to bloom profusely until late in August and melons may ripen that are set about the middle of August.

Twenty ripe melons to each vine is considered a heavy yield. In the above table we have more than 40 female flowers (to each hill) produced in the first two weeks of the blossoming period.

The first blossom appeared on June 27, and the first ripe melon was taken August 11. It takes about six weeks from the time of the setting for the fruit to ripen. Some farmers become alarmed when the first flowers that are formed drop without setting fruit, but the figures reveal the fact that the most of these are not fruit bearing flowers.

## INSECT PESTS OF THE CANTALOUPE.

*Flea beetle*—This is a small black beetle that devours the leaf soon after the melons are up. Dusting the plants with air slaked lime in early morning when they are damp, or spraying them with a mixture of 1 lb. of Paris green and 1 lb. of lime to 150 gallons of water, will remedy the trouble.

*Striped cucumber beetle*—This little striped insect is familiar to all, appearing in the spring soon after the melons



are up. It has not appeared at the station since June, 1898, at which time trials for its control were cut short by a severe hail storm. I have seen good results from dusting the plants with Paris green in air slacked lime, but it is only a repellant, and hence the effect is temporary. It will drive them away for a time, but they may return with the next passing wind. In the short space of time we were enabled to combat it, we found kerosene emulsion quite effective. It acts as a repellant and kills with sufficient contact.

In Bulletin 158 of the Geneva (N. Y.) station, Bordeaux mixture was found to be the most efficient of many remedies tried. From a knowledge of its repellant properties, we are of the opinion that it will do all that is claimed for it. Its use will be a double one—for the insect and the blight. The insect is not present every year, but is very destructive when it does appear.

*Geometer or measuring worm*—This worm did much harm in 1900 by eating away the parenchyma of the leaf from the under side. It appeared about June 18 and was very near the color of the leaf, and exceedingly small. It was sometimes difficult to discern, and did much injury before many were aware of its presence. These worms are numerous every year on lettuce, cabbage, etc., but last year was the first time I have known them to attack cantaloupes. I noticed when we had sprayed with Bordeaux mixture for the blight, that but few of the worms were present.

We also used a spray of Paris green, 1 lb. and lime, 1 lb. to 150 gallons of water, which was effective. In using Bordeaux mixture for the blight the poison can be added to lessen the numbers of the insect, and thus apply a remedy for both evils at the same time.

*Melon louse*—This is the only insect that may cause alarm to the melon growers. In the eastern part of the valley it has secured such a hold that drastic measures will probably have to be taken for its suppression. I saw many melon fields in 1900 almost ruined by this insect. The insects were so numerous that the vines over whole fields were black from the excretion of honey-dew. They were so numerous as to cause inconvenience to the pickers, and yet there were many growers not aware that the insect was present in the field. The lice were sapping the vitality of the vines and destroying the quality of the product.

The insect breeds and feeds upon a great variety of plants, many of which are the common weeds of our fields. Winged forms will appear and migrate to the melons. The

lice reproduce so rapidly that once they become established it may be only a short time until the whole field is infested.

Probably the best remedy is a preventive one, which consists in keeping the weeds cleared from surrounding fields, and the burning or plowing under of all vines and rubbish in the fall. Close watch should be kept early in the season, when hoeing and thinning, for any appearance of the insect.

It is a small, green insect that attaches itself to the under side of the leaf. Close observation is necessary to discern it when it first appears. The insect secures its sustenance by sucking the sap from the leaf, and only contact remedies, such as kerosene emulsion, will be of service.

If but few hills are attacked, they may be destroyed, but this is not desirable. If the field becomes infested with this insect, spray the under side of the leaves thoroughly with the kerosene emulsion (diluted 30 times) to keep it in check. As soon as the melons are harvested, put in the plow with rolling coulter attached and turn the vines under deeply. Do not use the same land to grow melons the succeeding year.



# The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

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AGRICULTURAL EXPERIMENT STATION,  
UNIVERSITY OF COLORADO

## SUGAR BEETS.

A RÉSUMÉ OF THE WORK DONE BY THE AGRICULTURAL  
EXPERIMENT STATION OF COLORADO.

—BY—

WILLIAM P. HEADDEN.

# The Agricultural Experiment Station

FORT COLLINS, COLORADO.

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# INTRODUCTORY.

BY THE DIRECTOR.

Since 1889 the Colorado Experiment Station has issued ten bulletins relating to sugar beets, eight of which have been devoted entirely and two partially to the study. Nearly all of these bulletins are now out of print, but demands still continue for the information contained in them. It is not desirable to reprint these bulletins, yet many of the investigations and conclusions are still pertinent, and it is believed that a summary of these bulletins to render the results accessible will be of much use, and incidentally serve to maintain the credit of the Station for the pioneer work on this subject which it has done in this State, the extent of which is realized by few. The bulletin places the facts developed in the published reports of this Station in compact form, and while attempting to summarize our own publications referred to, it does not attempt to summarize the work of the other stations or of the Department of Agriculture on the same subject.

This early and continuous work of the Station carried on since 1888, and supported in 1898, as it has been, by various interests, especially of the Denver Chamber of Commerce and the C. & S. R. R., has been an important factor in the location of the industry in Colorado on a firm foundation. These investigations have given the data necessary in order that sugar beet factories should be justified. At this time three factories (Grand Junction, Rockyford, and Sugar City) are in operation in the State. Another (at Loveland) is in active construction, and several more are in contemplation for 1902. The industry has every promise of being of much importance to the State, and especially valuable as it does not interfere with any other. The results already reached show that it finds in Colorado, as has been indicated in the early reports of the Experiment Station, a state well adapted to the industry.

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7. Potatoes and Sugar Beets. April, 1889. Profs. Cassidy and O'Brine.
  11. Sugar Beets. April, 1890. Director Ingersoll and Dr. O'Brine.
  14. Progress Bulletin on Sugar Beets. January, 1891. Dr. O'Brine.
  21. Sugar Beets; Potatoes; Fruit Raising. October, 1892. F. L. Watrous.
  36. Sugar Beets. March, 1897. Prof. Cooke and Dr. Headden.
  42. Sugar Beets in Colorado in 1897. February, 1898. Prof. Cooke and Dr. Headden.
  46. A Soil Study. Part I. The Crop Grown: Sugar Beets. June, 1898. Dr. Headden.
  51. Sugar Beets in Colorado in 1898. March, 1899. Prof. Cooke.
  57. Farm Notes. Alfalfa; Corn; Potatoes; Sugar Beets. July, 1900. Prof. Cooke.
  58. A Soil Study. Part II. The Crop Grown: Sugar Beets. August, 1900. Dr. Headden.

## PRESS BULLETINS.

1. The Sugar Beet Caterpillar. August, 1899. Prof. Gillette.
3. The Beet Army-Worm. May, 1900. Prof. Gillette.

Also, references in each of the thirteen Annual Reports of the Station.

# SUGAR BEETS.

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## A RÉSUMÉ OF THE PUBLISHED WORK OF THE AGRICULTURAL EXPERIMENT STATION OF COLORADO.

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BY WILLIAM P. HEADDEN, PH. D.

The first experiments made in the State of Colorado to determine the feasibility of growing sugar beets for the manufacture of sugar on a commercial scale were those made at the Experiment Station at Fort Collins in 1888. These were undertaken by Professors Cassidy and O'Brine at the instigation of the late C. L. Ingersoll, Director of the Station. Three varieties were experimented with. The percentage of sugar was quite satisfactory, the authors making the yield of cane sugar from 4,250 to 7,318 pounds per acre.

The object of these experiments is evident from the closing paragraphs of bulletin No. 7,\* in which the work is recorded:

"From the above it will be seen that there is quite a wide variation in sugar content in the four varieties tried last season. Enough, however, has been developed to create a lively interest in the cultivation of the sugar beet in this State for the purposes of sugar production—"

From the publication of the results of these first experiments, in April 1889, to the present time, the Station has issued eight other publications on this subject, only one of which republished any of the results contained in previous bulletins.

The work on this subject has taken two directions, cultural and chemical. Bulletins 11, 46, and 58 are devoted to considerations of the latter class; Nos. 7, 14, 21, 36, 42, 51, and 57 almost exclusively to cultural studies, No. 14 alone deviating from this line in containing a statement of the Director and Chemist in regard to the state of the industry in 1890.

In No. 14 the question of the relation between the size of the beet and its sugar content was discussed, and the suggestion made that the size of the beets could be controlled by thick seeding and judicious thinning.

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\* Potatoes and Sugar Beets. April, 1889. Profs. Cassidy and O'Brine.



The results given are uniform in showing that small beets, such as weigh from one to three ounces, are richer than large ones, thirty to forty ounces in weight, by two per cent. or more.

The conclusion of this bulletin indicates that the author had the general question of the adaptability of Colorado to the production of sugar beets in view rather than any cultural problem, for he says, "*We believe that it has been established that the soil and climate of Colorado are favorable to the production of sugar beets, and that they can be successfully and profitably raised to the advantage, both of the farmer and manufacturer.*"

Mr. Frank Watrous, in charge of the substation at Rockyford, grew beets in 1890, '91, and '92, and records the results of his experiments in bulletin No. 21. The season of 1890 was spent in groping after facts, and the product, though encouraging, was not large. The yield obtained ranged from eight to seventeen tons per acre. Some of these yields were from half acre plots, others estimated from single rows.

In 1891 an experiment in irrigating beets was made, from which Mr. Watrous concludes that, in an ordinary season, one irrigation during the growing season is sufficient to produce the best results both as to tonnage per acre and saccharine matter contained. Four plots of one-fourth acre each were planted to Vilmorin beets. Plot 1 was not irrigated; plot 2 was irrigated once; plot 3 was irrigated twice; and plot 4 was irrigated three times. The dates of irrigation are not given. The results are:

Plot 1. Yield: 9 tons per acre. Sugar: 14.25 per cent. Purity: 80.5 per cent.

Plot 2. Yield: 10.8 tons per acre. Sugar: 15.2 per cent. Purity: 84.3 per cent.

Plot 3. Yield: 9.9 tons per acre. Sugar: 14.22 per cent. Purity: 79.5 per cent.

Plot 4. Yield: 9.9 tons per acre. Sugar: 13.0 per cent. Purity: 76.0 per cent.

In 1892 the plots were 1-100 and  $\frac{1}{4}$  acre each, four of the sixteen plots being  $\frac{1}{4}$  acre in area. The yields from the  $\frac{1}{4}$  acre plots were 18.7 tons, 20.5 tons, 25.0 tons, and 25.7 tons per acre, and the sugar percentage 15.18, 16.7, 15.9, and 18.9. The coefficient of purity was between 82 and 85. The yield from the 1-100 acre plots was somewhat higher, as was to be expected, the sugar content ranging from 13 to 15.8 per cent., and the coefficient of purity from 76 to 85.

The plan of culture adopted as the result of the three years' study is as follows: After land had been plowed, harrowed, and made quite smooth, even, and free from lumps, stones, or trash, seed

was sown with an ordinary hand drill, sowing eighteen pounds to the acre, covering an inch or less in depth, in double rows one foot apart, separated by a space two feet wide. Then, with one horse and a shovel plow, a trench was made in this space, the dirt being thrown on both sides to finish covering the seed. The rows are worked over quickly with a rake or hoe, and the seeding is complete. Beet seed requires considerable moisture to produce germination, hence, in a dry spring, water may be turned in these ditches and beets brought forward, independent of dry weather.

To facilitate irrigation, rows should not be more than three hundred feet in length, preferably less. It should not be necessary to drench the upper end in order to moisten the lower end.

Proper cultivation consists in hand hoeing or working with a fine-toothed cultivator, the surface of the ground being stirred as soon after irrigation as practicable. From experience at this Station it seems safe to state that the more careful cultivation, with the proper amount of water when needed, the more sugar per acre.

Bulletin No. 36 discusses the general outlook for the sugar industry in Colorado. The question of market for the sugar which might be produced in the State is answered as follows: "To produce the sugar consumed by the inhabitants of Colorado would require five factories of large size, employing two hundred men each, who, with their families, would represent about four thousand people. It would require the growing of sugar beets on fifteen thousand acres of land, and add more than three hundred dollars to the income of each of two thousand farms."

Touching the question of profit, the writer says: "*If prices are such as to make the business profitable anywhere, then it will pay in Colorado.*"

The irrigable portions of Colorado below 5,000 feet in altitude and east of the Rocky Mountains, possess the best possible climate for the growth of sugar beets, as do many of the valleys of the western portion of the State, but the parks of Colorado are too cold for the sugar beet to be grown with profit.

The common cause of failure among beginners is a lack of thorough preparation of the soil. The plowing should be done in the fall, subsoiling to fifteen or eighteen inches. If this is done, a thorough harrowing just before planting will be all that is needed.

If the plowing is done in the spring it should be delayed until just before planting. The planting is done with a drill. An ordinary wheat drill may be used, but there are special drills for planting beets. Twenty-four inches is recommended as the distance between rows, being none too far apart for irrigation.



The quantity of seed recommended to be sown is at the rate of twenty pounds to the acre. This quantity is large, but advisable in order to get a full stand. The seed should be put in about an inch and a half deep. If the ground is thoroughly wet at the time of planting half an inch may suffice. If the plowing is done in the spring it may be advisable to irrigate the ground thoroughly before plowing, and thus insure a good supply of moisture in the subsoil.

If, after the seed is sown, the weather is so dry that the seed has to be "irrigated up," the chances of a profitable crop are slight. The seed can be successfully "irrigated up" by running a furrow six inches from the drill and allowing a small head of water to run until it has wet the seed by soaking sideways.

The planting may be done from the last of March till the middle of June. Sugar beets sown the first of May will be ready for harvesting about the first of October.

The first cultivation should take place as soon as the plants are up enough to enable one to follow the row. Whatever implement is used, it should merely scratch the surface of the ground, leaving it level and killing the small weeds without throwing dirt onto the young plants. The weeds must be kept down. The ground should be cultivated after each irrigation to level the ground and make a dirt mulch on top to preserve the moisture.

The beet crop in Colorado will need one, and possibly two or three, irrigations. The last irrigation should be given about six weeks before the crop is mature.\* In 1895 a heavy rain in September kept the beet crop in full growth until frost, and produced a crop with much less than the usual amount of sugar.

The plants should be thinned when they have four leaves, leaving but one plant in a place. The distance between plants should be eight to ten inches. There is generally but little difference in the weight of the crop in cases where the beets stand six, eight, and ten inches apart. It is easy to grow beets weighing five pounds each, where the soil is rich, by thinning to twelve inches, but such beets are inferior to beets averaging less than two pounds for sugar, and also for stock feeding.

In thinning, the plants are cut out by means of a sharp hoe, leaving bunches of a few plants each, which must be thinned to a single plant by hand.

The soil of Colorado is generally rich enough to grow several crops of beets without fertilizing, but it must eventually be fertilized in order to maintain the yield.

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\* This is a general statement, and must be deviated from in special cases.—H

In case alfalfa ground is broken up beets should not be grown on it the first season, but rather a crop of wheat. This will put the soil in better condition and will rot the alfalfa roots. It is not advisable to grow beets more than two years in succession on the same ground.† Alkali ground may be an exception.

If barnyard manure is used to fertilize the soil, the beets can advantageously follow a crop of corn.

The best varieties are the Kleinwanzlebener and Vilmorin.

The harvesting is done either by means of a beet puller or by plowing a furrow near the beets and pulling them by hand.

The topping is done by means of a heavy knife. Topping machines have, as yet, not been successful.

The factories work on beets hauled directly from the field up to the time freezing weather sets in. Beets to be used in the later part of the season should be protected from freezing; for this purpose they may be put into shallow pits and covered with straw and dirt, either near the factory in pits provided by them, or in the field.

The cost of growing an acre of beets varies in different parts of the country, the size of area planted, the condition of the ground, etc. The range is from thirty to forty-five dollars, or from two to four dollars per ton.

About eleven tons of sugar beets per acre at four and a half dollars per ton is a fair average crop, with a possibility of a much larger yield. Compared with alfalfa or wheat, the return seems large, but much more labor is required to produce it.

Sugar beets have a high value for stock feeding. They have been fed at the College with good results, except where fed to steers. The beets seem to be too watery for profitable feeding to steers where the feeding is done out of doors in cold weather. It is advisable not to feed them to fattening lambs for the last six weeks before marketing, grain being preferable at this period, so that the flesh and fat may harden for shipment.\*

The tops are good feed for all classes of farm animals. They may be fed at once, as soon as harvested, or put in a silo and fed through the winter.

The next record of results occurs in bulletin No. 42. In 1897 we made an effort to enlist persons in different parts of the State in the raising of sugar beets. The Station has already established beyond any doubt the adaptability of both the soil and climate of this

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† Without fertilization.

\* The author does not make any statement as to the extent to which grain should replace the beets at this period, whether wholly or only partially.—H.



section of the State to the cultivation of the sugar beet, and also of that of the Arkansas valley, where the substation at Rockyford is located, but no co-operative work, including all sections of the State, had been entered upon. The Station received from the Department of Agriculture at Washington, five hundred pounds of beet seed, and from A. Keilholz, Quedlinburg, Germany, two hundred pounds. This seed was sent to six hundred and eleven persons residing in in forty-seven counties of the State. Most of the analyses of these beets were made by the Department of Agriculture in Washington. The State was divided into five sections, as follows:

1. The valley of the South Platte and its tributaries.
2. The Divide south of Denver, where crops are raised without irrigation.
3. The valley of the Arkansas.
4. The valley of the Grand.
5. The San Luis valley.

The varieties used were the Kleinwanzlebener, Vilmorin, and the Imperial White. As there were one hundred and six samples of the Kleinwanzlebener variety out of the one hundred and twenty-five recorded, no distinction is made between the varieties in this summary.

The percentage of sugar in the samples from the Platte valley ranged from 11.5 to 20.0, the coefficient of purity from 73 to 86, and the crop in tons from 9 to 47.

The percentage of sugar in the samples from the Divide section, grown without irrigation, ranged from 11 to 18, the coefficient of purity ranged from 71 to 87, and the yield in tons from 9 to 22.

The percentage of sugar in the samples from the Arkansas valley ranged from 12 to 20, coefficient of purity from 73 to 86, and the crop in tons from 12 to 40.

The samples from the Grand valley showed percentages of sugar ranging from 12 to 19, coefficients of purity ranging from 74 to 86, and crops from 15 to 42 tons.

The samples from the San Luis valley \* showed percentages of sugar ranging from 11.5 to 17.9, coefficients of purity from 74.2 to 86.9.

The time of ripening of beets in Colorado will vary, of course, but the average of the samples taken between September 25th and October 10th is 14.1 per cent. sugar and 80.7 per cent. purity, which is an excellent grade of beet. To get the crop to ripen is the principal aim of the beet grower. The most important factor in this is

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\* Altitude 7546 feet.

that the beet shall be kept growing all the time from the sprouting of the seed until the harvest. Some of the conditions on which the ripening of the crop depends are beyond the control of the grower. In Colorado it is true in general that the crop will not ripen until the vigor of growth has been checked by frost. The best means of determining whether a crop is ripe or not, that is, in condition to go to the factory, is by means of an analysis, but a good judgment can be formed by cutting a beet and noticing the rate at which the cut surfaces darken.

The increase in percentage of sugar and coefficient of purity during ripening is about three per cent. for the former and about five per cent. for the latter.

Some very suggestive facts relative to methods of culture were observed during this year's study. Certain principles of beet growing have come to be considered as essential to the production of the best beets. These principles were violated by most of the growers of beets this year, it being their first experience, and yet they obtained good results. It is said that beets should never be planted on new ground. This was violated with good results, giving, in one case, beets of 15.2 per cent. sugar and 82.4 per cent. purity, and in another 19.4 per cent. sugar, and in others the beets were above the average. Ground which had been broken but one year gave uniformly good results. So, too, in regard to time of plowing and subsoiling. All writers on sugar beet culture agree that beets should not be planted on ground that has been recently manured. Sixteen persons report manuring with stable manure. The crops were late in ripening, but with three exceptions, the quality was good. The results as a whole indicate much more gain than loss from the application of stable manure.

The hardest part of beet raising is to get a full stand all over the field. The poor growth of the seed is due to lack of moisture, too deep planting, and poorly prepared ground. The lack of moisture can be overcome in two ways—by irrigating before or after planting the seed. The latter seems to be more promising as a general method. Of fifteen persons trying this method, eight report having obtained a thick stand, being twice as large in proportion as those reporting a thick stand by depending on rain or the original moisture in the ground.

Mr. Geo. H. West, of Greeley, contributed an interesting article, published in bulletin No. 42, containing the observations and conclusions of his study of the subject, which he designates "Growing Sugar Beets for Factories." Mr. West studied this subject in Nebraska, Utah, and New Mexico. Of the growing of beets in Nebraska he says: The farmers are largely Germans, with some Rus-



sians. Women and children work with the men in the fields. Where a large acreage is in beets, the thinning, weeding, hoeing, pulling, and topping is done by contract. Laborers receive from fifteen to twenty dollars per month, the usual wages by the day being one dollar and board. On contract work the rate is from fifty cents to one dollar for boys; one dollar for men and women, without board. For a man and team, two dollars and fifty cents per day; for man and horse, one dollar and seventy-five cents. Land rent from three dollars and fifty cents to six dollars per acre.

The average yield in 1897 was 7.25 tons, and the sugar extracted by the factory at Norfolk was 10.95 per cent. The percentage of sugar in the beets was 13.1 per cent., purity 81.5 per cent.

The Grand Island beet raisers averaged 8.1 tons per acre. The average percentage of sugar in the beets in 1897 is said to have been 12.87, and purity 79.5. The percentage of sugar obtained from these beets by the factory was 8.72.

The tables given show that in 1897 the factories at Norfolk and Grand Island treated the largest tonnage and made the highest saving attained up to that year. The range of farm wages is from fourteen to twenty dollars per month, with board; and from one dollar to a dollar and a quarter by the day. Women and children generally work on the contract plan. Many girls get a dollar a day in the beet fields, and prefer it to house work. Boys from ten to eighteen years of age receive from fifty to eighty cents per day, a man and team two dollars and fifty cents, and a man and horse one dollar and seventy-five cents per day. Contracts can occasionally be made, as in Colorado, at two dollars per day for man and team. Land rentals range from four dollars to seven dollars per acre. The crop of 1897 is said to have been reduced fully one-third by drought. No beets are grown by irrigation in Nebraska.

At Lehi, Utah, the conditions are said to be ideal for the growing of beets and running a sugar factory. The farms vary from five to forty acres in extent, and fully nine-tenths of them are worked by the owners. Mortgages are rare and the farmers prosperous. The women do not work in the fields, and the girls seldom work there unless at home. Much of the hand labor is done by boys. The average acreage per grower is less than four acres. The highest average yield per acre was in 1896, 13.5 tons. The average per acre from 1891 to 1897, inclusive, was 9.44 tons. The highest average percentage of sugar in the beets was, in 1896, 13.9 per cent. The average percentage from 1891 to 1897, inclusive, was 12.4 per cent. The average percentage of sugar extracted, 1891 to 1897 inclusive, was 8.46. Land rentals range from \$7.50 to \$15.00. The soil shows a

great diversity about Lehi, but is generally a heavier soil than the uplands of northern Colorado.

The Eddy, New Mexico, sugar beet factory has been run for two seasons only, 1896 and 1897. The valley, though a natural fruit garden, lacks the farming population, and perhaps, too, the close, careful cultivation and knowledge of irrigation of the older farm districts of Colorado. In 1897 they grew 1,900 acres of beets; yield, three tons per acre; percentage of sugar, 14.2; purity, 80 per cent.; percentage of sugar extracted from the beets, 10.53.

The average cost of growing and delivering a crop of beets at Norfolk, Nebraska, is \$26.50 per acre; the average profit, \$11.04. The yields range from five to fifteen tons per acre. The net returns vary from a profit of \$29.00 to a loss of \$7.55 per acre. At Grand Island, Nebraska, the average was \$28.73 per acre, and the average profit \$9.27. The yield varied from five to twelve tons per acre, and the net results from a profit of \$17.00 to a loss of \$12.00 per acre. Mr. West puts the average cost of growing and marketing sugar beets in Nebraska at \$30.00 per acre, and states that the officials of both factories put it at the value of seven tons of beets, or \$28.00.

The average cost of growing beets in Utah, not including land rentals, is put at \$32.50 per acre. The average yield is stated at 10.1 tons, but the yield for 1897 was 6.75 tons. Improved beet cultivating implements had not, at that time, been introduced into Utah, and this, with the higher land rental and cost of irrigation, raises the actual cost to probably \$40.00 per acre.

Relative to the profits of beet culture, Mr. West says: Large yields are regularly obtained by those farmers who do thorough, clean work, and intimates that therein lies a big secret of success.

It is also pointed out that the labor question is a most serious problem in this industry. It is too important to be entirely passed over, even in a summary such as this.

Concerning the feeding of pulp to cattle and sheep he gives results obtained in Nebraska and Utah. At Lehi the pulp is placed in silos with addition of about one-half per cent. of its weight of salt. The cattle always have access to plenty of hay, pulp, and water. *They never feed a pound of grain in fattening the stock, unless the pulp gives out.*

John Reimers, Grand Island, Nebraska, had had three years' experience in feeding pulp to cattle. He fed fifty pounds of pulp, twenty pounds of corn meal, a little bran, and oil cake, and the usual amount of hay per day, as a full ration. Hake Bros., also of Grand Island, fed lambs a mixture of four pounds of pulp to one or one and a half pounds of corn meal, besides hay, as a full ration.



The results are highly satisfactory. The pulp is said by Superintendent Geo. Austin, of Lehi, to give the best results after fermenting in the silos for thirty days, and should not be fed sooner than this.

The experiments made in 1898 are grouped as follows in bulletin No. 51:

1. *Different dates of planting.* Results in favor of early planting in respect to yield, sugar content, and purity.

2. *Planting on freshly plowed ground as compared with planting on ground plowed a few days before planting.* Resulted in favor of planting on freshly plowed ground by 2.3 tons in yield, two per cent. in purity, and a slight excess in sugar.

3. *Seed irrigated at planting as compared with that not irrigated.* Results obtained on the College Farm showed no advantage from this practice. The soil was a rather heavy loam and was moist at planting time. Good results have been observed from this practice on lighter soils.

4. *Soaking seed before planting.* Results did not show any gain from the soaking of the seed.

5. *Sowing at the bottom of a three-inch furrow.* The resulting stand was not so good as that obtained by sowing at ordinary depths. The yield was once as good and twice poorer than that from similar rows of ordinary planting. The percentage of sugar and purity were not perceptibly different from other plantings.

6. *Different depths of planting.* The depths at which the seed was planted were from one-half an inch to an inch and a half. The first series, planted May 11th in a wet soil, showed no difference, but the later planting, made May 27th when the soil had dried out considerably, showed an advantage in favor of the deepest planting, amounting in comparison with the shallower plantings to more than one-third of the crop. The stand, yield, and quality were all better than in the cases of shallower planting.

7. *Transplanting.* Transplanted beets are usually ill-shaped. The yield may be good, percentage of sugar and purity high, but the method would not be a financial success.

8. *Different distances of thinning.* The results obtained show that the distance apart of the beets, from four to ten inches, has but slight influence on the quality of the crop as to sugar and purity. In a general way the thicker stand tends to a larger yield, but there are exceptions to this statement.

9. *Different dates of thinning.* The results show that the

thinning of beets can be extended over a period of two weeks without injury to the crop.

10. *Variety tests.* Six varieties, Zehringen; Vilmorin's Improved, grown in Russia; Kleinwanzlebener, grown by Vilmorin; Pitschke's Elite; Vilmorin's French, very rich; and Schreiber's Elite were grown side by side with Kleinwanzlebener, strain not given, with almost identical results in percentage of sugar and purity, the sugar ranging from 15 to 17.20 per cent., and the purity from 76 to 81.9. The average of all the samples analyzed in this test is 16.04 per cent. sugar, and 78.9 purity.

11. *Number of irrigations.* At Rockyford, beets were grown without irrigation, with one, and with four irrigations. This experiment was of little value, being defeated by the unusually heavy rains of that season.

At Pueblo, Mr. C. K. McHarg applied water to one-half of some experimental plots twice after the 20th of August, the other half receiving none after that date. The two later irrigations produced an increase of one-seventh in the weight of the crop, and the percentage of sugar was increased; beets from the half irrigated late, contained 16.42 per cent. sugar, 81.0 purity, and those from the other half contained 15.79 per cent. sugar, 81.7 purity.

12. *American grown seed vs. imported seed.* Two samples of American grown seed were used, one grown in Utah and the other in New Mexico, both were strains of Kleinwanzlebener beets. The imported seeds were the Original Kleinwanzlebener, Vilmorin, Mangold, and Elite Kleinwanzlebener.

The Elite Kleinwanzlebener and the Vilmorin were sent us by the U. S. Department of Agriculture as the best beet seed that they could get. The Original Kleinwanzlebener was selected by the Utah Sugar Company as, in their judgment, the best brand of seed on the market from which to raise their own seed. The Utah grown seed produced as large a crop and one richer in sugar and purity than the average of these three. It excels its parent strain in richness and purity, and is but little inferior in quality of crop.

The New Mexico seed equals the Vilmorin and is not far behind the original Kleinwanzlebener.

The germinating quality of the seed is quite satisfactory.

In 1899 the questions whose solution were attempted were:

*Does it pay to subsoil?* The results of ten tests made at this Station show an average gain of 18 per cent. in the weight of the crop as the result of subsoiling.

*Is it advisable to plant the beet seed very early?* The average



crop from ten plots sown between April 10th and 20th was 27.7 tons; from ten plots sown between May 1st and 10th was 24.3 tons; from ten plots sown between May 15th and 26th was 20.4 tons; and from ten plots sown between May 31st and June 10th was 15.3.

The percentage of sugar in these various crops scarcely differed at all, 0.76 of one per cent. being the maximum difference, and 3.2 was the maximum difference in purity. The difference in crop, however, is very decidedly in favor of very early planting.

The question of the distance between rows is recurred to again, and a former recommendation is repeated, *i. e.*, making the alternate spaces between rows narrower and wider. The distances advocated are eleven and twenty-seven inches. The chief advantage claimed is in irrigating, also an increase of crop.

#### IRRIGATING UP THE SEED.

Twelve experiments were made with irrigating up the seed, and a like number without irrigation. Of the twelve experiments with irrigation none failed, of those without irrigation two failed. The crops from the twelve irrigated at the time of planting averaged 26.3 tons to the acre. The crops from the ten plots which came up, but which were not irrigated at the time of planting, averaged 25.4 tons to the acre.

#### INSECTS INJURIOUS TO BEETS.

The earliest observations on this subject seem to have been made by Prof. C. P. Gillette in 1894, when he records the leaf hoppers *Gnathodus abdominalis*, *Platymetopius acutus*, and *Agallia uhleri*, as doing injury to beets in the vicinity of Grand Junction, also a mealy bug, *Dactylopius solani*, as infesting the crowns of the plant. The next mention of injury to beets by insects is in 1897, when the writer's patch of beets was seriously injured by the leaf hoppers *Agallia uhleri*, *A. sanguineolenta*, *A. cinerea*, and the striped beetle *Systena taeniata*. Later *Monoxia puncticollis*, and also the blister beetle, *Macrobases unicolor*, did some damage.

In 1899 the beet army-worm (*Laphygma flavimaculata*) made its appearance near Grand Junction, and was very destructive. It did not appear in injurious numbers in this locality in 1900. Prof. Gillette and his assistant, Mr. E. D. Ball, found but few specimens of either the first or second brood. Prof. Gillette (Thirteenth Annual Report of the Colorado Agricultural Experiment Station) says of this failure of the insect to appear the second season: The very sudden appearance of this insect, which had never before been considered injurious, in such destructive numbers, and its equally sudden disappearance, is quite remarkable. Particularly is this so from the fact that the fall brood of worms in 1899 were but little parasitized, and the moths matured in enormous numbers. The latter

must have failed, for some reason, to winter over. These worms appeared on some experimental patches of beets at Lamar and Rockyford in 1899, and the first brood appeared in destructive numbers in 1900. The worms began to appear during the first week in June, and were abundant by the 14th, when spraying was begun. Late planted beets were not injured by them, except where they were planted near patches of weeds or earlier beets. The poisons were effectual, especially where two sprayings were made with Paris green.

Other insects mentioned by Prof. Gillette as having been observed on beets and not already mentioned, are *Nysius angustatus* (often called false cinch bug), more or less abundant everywhere, in some cases causing beets to wilt and die. *Deilephila lineata* was found as an occasional feeder, especially where purslane was allowed to grow. (Mr. Ball's notes.)

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## Chemical Considerations, Bulletin No. 46.

### THE EFFECTS OF ALKALI.

Sodic carbonate, or black alkali, when present in quantities equal to less than 0.1 per cent. of the weight of the dry soil, does not prevent a satisfactory germination, but a still smaller quantity, as little as 0.05 per cent. of the weight of the dry soil, will corrode the plants, both plumule and radical, causing their death. We have occasionally observed corroded plants in alkali ground, but in spots only. The ground experimented with was very strongly alkalized, the worst, in fact, that we had at our disposal.

Sodic sulfate, or white alkali, does not prevent germination when present in quantities equal to less than 0.70 per cent. of the weight of the dry soil. No corroding by this salt has been observed.

The effect of the black alkali, sodic carbonate, is not mitigated by the presence of the white alkali. The sodic salts hasten germination by 36 to 48 hours.

Magnesium sulfate, one of the constituents of our alkalies, retards but does not prevent germination.

The beet plant can endure a larger amount of white alkali in the soil after it has become established.

Alkalinity of soil did not effect date of ripening in a series of experiments made at the Station.



Alkali does not affect the sugar content of beets grown on soil in good, or even fair tilth.

The ripening of beets may be seriously affected by a rainfall, or untimely irrigation. The crop of 1897 showed this plainly. On September 8th the beets had already begun to ripen, from the 10th to the 14th; 0.74 inches of rain fell; on September 22nd the samples analyzed showed a lowering in the percentage of sugar present. This loss was not regained for nearly three weeks, the beets, however, increased greatly in size during this time.

The ripening in this case took place more suddenly than is probably usual, and corresponded to an increase of from 2 to 3.5 per cent. in the different plots and is equivalent to about one-third of the total yield of sugar—that is, if the yield of sugar be 6,000 pounds per acre, 2,000 pounds is formed during the period of ripening.

Beets were covered with straw and left undug until January 7, 1898, with a slight gain in percentage of sugar and purity, showing that beets under favorable conditions may remain unharvested without loss of sugar or weight of crop.

Distribution of the sugar in the beets. In bulletin No. 11, it is stated that the amount of sugar increases in the successive sections of a beet from the top downward. This is not sustained by bulletin 42, which shows that the upper third, including the crown, contains only about 0.2 of one per cent. less sugar than the lower two-thirds, and these, the lower two-thirds, cannot be said to differ at all; sometimes the second and sometimes the third third having the higher percentage of sugar, the difference always being so small that it is insignificant.

#### SUGAR IN THE CROWNS.

The crown as used in bulletin No. 42, is really a structural portion of the beet, and not any indefinite portion which may have chanced to grow above the ground. It is very rarely the case that sugar beets, Kleinwanzlebener or Vilmorin, grow above ground at all with us. The difference between the sugar content of the crown and the beet from which it is cut is about one per cent. The coefficient of purity is lower than that of the beet, but not necessarily poor. The example given shows beets 16.1 per cent. sugar, 88.0 purity; crowns 15.1 per cent. sugar, 82.4 purity.

#### EFFECT OF FREEZING ON BEETS.

Simple freezing does not cause any change in the sugar. If thawing can be prevented the crop is not necessarily lost if frozen.

## DRYING OUT OF BEETS.

This takes place rapidly if the beets are exposed. Beets wrapped in paper and placed on the earth of a cellar bottom lost about five per cent. of their weight during the first twenty-four hours ; from this the daily loss fell to about two per cent., at which rate the beets continued to lose up to the seventeenth day. The percentage of sugar increased.

The drying out of beets has another effect, it is accompanied by a loss of sugar. This loss varied in the experiments recorded from one-fortieth to one-sixth of the sugar present.

The suggestion is made that the loss may be materially influenced by the condition of the crop, the loss being greater in unripe beets than in riper ones.

The yields recorded range from 7.9 to 11.8 tons per acre for sugar beets, and 15.9 tons per acre for Lane's Imperial.

The ratio of the weight of the tops to that of the beets was found in two ways. First, weighing the carefully removed tops and beets gave for sugar beets of different varieties ratios varying from 1:1.087 to 1:1.274, or the weight of the tops varied from 78.5 per cent. to 92.0 per cent. of the weight of the beets. The second method was to weigh the beets as harvested and the tops as removed from them. On removing these tops no part of the crown of the beet was taken. The result was that we found the ratio to be 1:1.14. The general ratio obtained by the first method was 1:1.12. The weight of leaves as harvested in the field equalled 87.7 per cent. of the weight of the roots. The results obtained in the laboratory gave their weight as equal to 89 per cent. of that of the beets.

The tops of beets grown on alkalized ground were relatively a little heavier than in cases where the ground was practically free from alkali.

The tops increase but little in weight during the last six weeks of the growing season. The beets, on the other hand, gained 64 per cent. of their weight at the beginning of this period.

The beets ripened this season, 1897, the second week in October, and about one third of the total crop of sugar was deposited during this period.

The percentage of dry matter in sugar beets increases with the maturing of the beet. In green beets harvested September 2nd we found from 8.8 to 14.6 per cent., with an average of 12.1 per cent. In mature beets it ranges from 17.0 to 20.5 per cent., and in exceptionally favorable seasons it may be higher. Sugar forms a larger percentage of this dry matter in mature beets than in green or immature beets.



There is a little more dry matter in the top one third of the beet than in the other two thirds.

Stock beets contain less dry matter than sugar beets. We found the dry matter ranging from 12.25 to 14.63 per cent. in mature beets.

The marc or pulp, the portion left after the sugar and soluble matters have been washed out, ranged from 4.21 to 5.25 per cent. The average is about five per cent.

For fodder analyses of sugar beets grown on alkali soil and soil free from alkali, of stock beets, beet tops, and marc or pulp, see bulletin No. 46, page 37.

Alkali in the soil tends to increase the percentages of ash and albuminoids.

The feeding value of dry pulp may safely be estimated as equal, pound for pound, to the dry sugar beet.

One ton of sugar beets yields about four hundred pounds of dry matter, and only one hundred pounds of dry pulp. One ton of stock beets yields about two hundred and forty pounds of dry matter, which is richer in albuminoids and nitrogen-free extract than the pulp is; the pulp, however, is a by-product and the stock beets are not.

The percentage of crude fiber in beets is quite irregular, but uniformly higher in beets from alkalized ground than others.

Alkali affects the composition of the beets more than that of the leaves.

The percentage of ash in the beet ranged from 0.79 to 1.33 per cent. in immature beets, samples harvested September 2nd, to from 0.95 to 1.39 per cent. in mature beets harvested October 13th. The average is 1.10 per cent. of ash in the fresh beet.

Fifty-eight per cent. of the total ash constituents removed from the soil by the roots, and 70 per cent. of all the mineral constituents removed by the leaves, had been gathered by September 2nd. The accumulation of ash constituents continues until the period of ripening.

The slight decrease in the percentage of ash as the roots approach maturity is due to the rapid increase in the weight of the beets. There is no diminution in the amount of ash constituents in the crop.

The influence of alkali, present in large quantities, is to increase the ash by about two per cent., reckoned on the dry matter.

The ash is quite evenly distributed throughout the beet, with a slightly larger amount in the top one-third, but the percentage of ash is higher in the dry matter of the bottom third.

The ash of the beet has a pretty uniform composition, generally showing about 3.5 per cent. sulfuric acid, 7 to 9 (usually about 8.5) per cent. phosphoric acid, 48 to 52 per cent. of alkalis, 2 to 3 per cent. of lime, about 6 per cent. of magnesia, 11.5 to 14.5 per cent. of chlorin, and about 15 per cent. of carbonic acid in the fine ash. When the carbonic acid is higher than 15 per cent. either the phosphoric acid or the chlorin is correspondingly lowered.

The composition of the ash of the leaves is quite different from the composition of the ash of the roots. The ash of the leaves contains from 3.5 to 3.9 per cent. of sulfuric acid, 1.8 to 2.3 per cent. of phosphoric acid, 23.7 to 25.7 per cent. of potash, 22.3 to 25.5 per cent. of soda, 1.5 to 2.5 per cent. of lime, 6 per cent. of magnesia, 23.3 to 28.5 per cent. of chlorin, and from 10.6 to 15.0 per cent. of carbonic acid.

The composition of the ash of immature beets is the same as that of mature beets. The only exception to this statement seems to be the percentage of chlorin in the ash of the leaves, which increases so generally and uniformly that it suggests a relation between the degree of maturity and the quantity of chlorin.

The soil, repeatedly referred to as alkalized, contained chlorid of sodium, or salt, equal to 0.025 per cent. of the weight of the air dried soil. This gives us 2,800 pounds of salt in each acre of soil, taken to a depth of two feet. The total water soluble in this soil varies from 0.09 to 1.4 per cent. of the weight of the air dried soil, taken also to a depth of two feet. The higher figure gives us the immense quantity of 49.0 tons of alkali per acre, consisting of 16.33 tons of sodic sulfate, 17.64 tons calcic sulfate, 10.27 tons of magnesian sulfate, and 1.25 tons of ordinary salt.

Continued cropping to beets would soon show a perceptible reduction in this quantity of sodic chlorid, especially if the leaves were carefully removed, but the ground water is rich in salts, and is capable of replacing this, as well as the other "alkali" salts removed.

Stock beets, including leaves, remove, crop for crop, more soda salts than sugar beets do, but not ton for ton.

The chemical work of 1898 and 1899 is recorded in bulletin No. 58, which continues the study of the effect of soil conditions on the stand and quality of the beets, and the chemistry of the beet itself.



There were certain spots in which the seed failed to germinate, and the cause of this was not discovered. It was not explained by either a lack or an excess of moisture, nor was the alkali as excessive as in some other places.

The plot experimented with was the same as that used in 1897, the results of which appear in bulletin No. 42.

The rainfall for the months of July, August, September and October was 2.8 inches, the total amount received by the crop from the time of planting till harvested was about eight inches. The ground at the time of planting was wet, and the water plane was about two feet below the surface. The water fell about a foot in the next thirty days. An irrigation given July 8th to 11th did not suffice to raise the water to its earlier level, and it fell two feet in eleven days. The level of the ground water was not sensibly affected two hundred feet east of my plot by this irrigation. The water plane fell slowly from July 25th until early in October, when it reached its lowest point. The water plane from July 15th to October 10th ranged from three to four and one half feet below the surface at the east end of the plot, and there were but few beets in this section. At the upper and higher end of the plot the plane varied from 5.2 to 6 feet below, and the crop was excellent. In an intermediate section the water plane varied from 3.5 to 4.5 feet below the surface, with an abundance of alkali, and it yielded a good crop. The crop showed the need of water during the later part of the season, notwithstanding the high water plane. The ground had been kept as mellow as possible, and clean, having received five hoeings and five cultivatings. This plot of ground was put in beets in 1899, and needed no irrigating, it having been sub-irrigated this season from higher ground lying to the west of it. The wetness of the ground interfered with the cultivation of the crop, but the mechanical condition of the soil was so much improved over that of previous years that the cultivation was much easier. In 1899 this plot was soaked, August 31st to September 2nd, and the crop left to itself. The crop from this plot in 1897 was, taking an average of all varieties of sugar beets, about nine tons; in 1898, thirteen tons; in 1899, fourteen and one half tons to the acre. The increase in the crop is due to the betterment in the condition of the soil and a rather better stand.

Application of manure, sheep manure in this case, improved the stand by at least ten per cent.

The ripening of the crop of 1898 was entirely different from that of the crop of 1897. In 1897 there was a rainfall in September, on the 14th, which interrupted the ripening. In 1898 the crop developed continuously up to maturing. No sudden increase in the percentage of sugar was observed as in the preceding year, when the

increase was from 2 to 3.5 per cent. In 1898 the greatest gain observed, which could be attributed to ripening, was 1.4 per cent. The varieties grown by the Farm Department remained almost constant from October 3rd till October 22nd, in only one variety was there a gain of as much as one per cent. The ripening of the crop is much more gradual some seasons than others. The same observations were made in regard to the effect of the alkali upon the quantity of sugar, coefficient of purity, and time of maturing as were recorded in bulletin No. 46, namely, that the effect of the alkali is not detrimental.

The effect of the manure upon the sugar content and coefficient of purity, considering all of the tests, which, however, are not concordant with one another, is to lower both the sugar content by from 0.5 to 1.2 per cent. and the coefficient of purity by from 0.1 to 3.1 per cent.

The effect of the manure on the shape of the beet was bad, and this effect was uniform in the six comparative experiments which were conducted.

These effects of the manure were noticeable the second year after its application, but not in so marked a degree as they were the first year.

The result the second year is probably due to the failure of the manure to thoroughly rot and become incorporated with the soil.

Cut straw was also used as a dressing. Its effects were beneficial to the soil, but less in degree than those of the manure. Its effects upon the beets were not pronounced enough to permit the expression of a positive judgment. The results of this experiment are taken as corroborative of the opinion expressed elsewhere, that it is the mechanical condition of our alkali soils that preeminently needs improvement. That section of the plot which has been in the worst mechanical condition shows more alkali on the surface than the others. The water soluble in the soil, however, is greater in other portions of the plot. No attempt is made to formulate the relation existing between the mechanical condition of the soil and the amount of alkali present. These two factors are spoken of together as producing certain effects on the crop, but the opinion is expressed that the alkali, *per se*, is not the cause of these effects. This opinion is based upon the observation of spots where there is an abundance of alkali, but where the mechanical condition of the soil is better. No statement is made as to the extent of the influence of the alkali upon the mechanical condition of the soil. This point is left as an open question. The crops have improved each year, showing a mitigation of these conditions due to cultiva-



tion. This improvement is not due to drainage, for the water table has not been lowered and is seldom low enough to prevent capillarity from bringing moisture, and consequently salts, to the surface. An attempt was made to determine the direction and rate of the flow by introducing lithia salts into one of the wells, but it was found upon examination that the ground water contained lithia at all times.

The effect of seasonal differences upon the crop was noticed in the greater amount of dry matter in the beets in 1898 than in 1897. The difference in the percentage of dry matter attributable to the seasons was from 3.0 to 3.75 per cent., about one sixth of the total dry matter in the beets.

The question of the rate of drying out was taken up again with more care than in previous years, with about the same results, *i. e.*, that the loss for the first twenty-four hours was about five per cent. In this case, with a temperature of 57 to 66 degrees, the loss was 4.39 per cent. It fell to two per cent. in a few days, and remained at this figure for twelve days. The effect of drying out is shown in its effect on the average sugar percentage in 1898. In this year we analyzed 813 samples. The average percentage of sugar is found to be 15.12, without making any allowance for the drying out. We succeeded in obtaining fairly reliable data in 336 instances on which to base the deduction which should be made, and find it to be 1.5 per cent., which gives us an average of 13.62 per cent. for the crop.

The conclusions arrived at, as the result of many experiments to determine the relation existing between the size of the beets and their sugar content, are: That beets to be compared must be grown under the same conditions; that the conditions determining the percentage of sugar are so complex that no given weight can be accepted as a limit which, if exceeded, will indicate that the beet is not of proper richness and quality for the manufacture of sugar; that when the large size is due to an excessive supply of plant food, or an unduly large feeding ground and a constant and very abundant water supply, the beet is quite certain to be low in sugar, but this will be true of all beets, large or small, grown under such conditions.

Eight experiments, in which beets weighing less than one half a pound are compared with beets weighing more than two pounds, showed that the smaller beets were richer in seven instances and poorer in one. The maximum difference in favor of the smaller beets is one per cent., the least difference is 0.19 per cent. The average difference is 0.50 per cent. The beets above one half pound in weight make the crop. The coefficient of purity is better in the

larger beets, or at least as high as in the smaller ones. The conclusion drawn from another experiment is that too great a width between the rows tends to have the same effect as permitting beets to grow singly.

In 1898 it was observed that certain over-irrigated spots had turned yellow. Analysis showed that these beets were richer in sugar than the beets growing adjacent to them, but which had not been over-irrigated, by upwards of three per cent., and the coefficient of purity was much better, ten per cent. This clue was followed in 1899 with excellent results. The average percentage of sugar for beets grown by the Chemical Department in 1898 was 13.65. The average for all samples analyzed that season, 1898, was 13.62 per cent. The average for the season of 1899 was 14.69 per cent.\* The effect upon the tonnage of the crop was not determined, but it was not materially affected in any observed case.

This is unlike the effects of a late and inopportune rainfall. The bad effects of this are probably due to the condition of the crop at the time of the rainfall, and not particularly to the amount of water that falls.

Cultivation and manuring increased the amount of phosphoric acid taken up, but did not increase the percentage of ash in the fresh beet. The greatest effect seems to have been on the percentage of chlorin taken up, it having been lowered.

The percentages of phosphoric acid, lime and magnesia in the ashes of the samples of 1897 and 1898 were very nearly the same, but in 1899 the percentages of the two latter substances increased by one per cent. each.

The changes produced tend to bring the composition of the ashes more into harmony with the results of other observers, and indicate the tendency of cultivation and continued cropping to ameliorate the soil conditions and modify their effects upon the mineral matters taken up by the plants.

The effect of the manure was of two characters, mechanical and as a fertilizer.

The nitric acid in the ground waters was more variable and higher after than before the application of the manure.

The total solids were also higher during the season immediately following its application.

Heavy rains or an irrigation increase the amount of chlorin in

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\* The average of all varieties, manured and not manured. The average for the not manured sections was 15.34 per cent.



the ground water. The increase was more pronounced and of longer duration after the manure was applied. The effects of the straw upon the soil lead the writer to attribute the effects of the manure principally to the organic matter in it, improving the mechanical condition of the soil and bettering its biological conditions, as indicated by the increased amount of nitric acid formed.

Experiments made in 1897, 1898 and 1899 upon the effect of soaking beets in water at a temperature of about 42 degrees Fahrenheit for a period of seven days, resulted uniformly in showing an increase in the amount of sugar present, and also in the coefficient of purity.

The reducing power of beet pulp was determined by extracting the beets with 80 per cent. alcohol until the extract no longer reacted for sugar, then boiling with dilute hydrochloric acid and determining the reducing sugar thus formed and calculating it as pentose. The pentoses, or, as it is expressed in the bulletin, the reducing power, did not decrease as the beet matured. The rich beets showed higher percentages of pentoses than those showing lower percentages of sugar. The quantity of pentoses in stock beets is quite as great as that in sugar beets.

Soaking seemed to diminish the quantity of pentoses present.

The sugars present in the leaves of sugar beets in largest quantities are glucose and maltose. Cane sugar is present in small quantities only, or is entirely absent.

## CONCLUSIONS RELATIVE TO THE CULTURE OF SUGAR BEETS.

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A rich, loamy soil is best adapted to the growing of sugar beets, but any soil that will produce good crops of grain will grow beets, and even soils too alkali to grow grains will grow beets.

Plowing is best done in the fall, subsoiling to fifteen or eighteen inches. Plowing may be done in the spring; in this case it is best to plow immediately before planting. In either case harrow quite smooth and even.

Results at this Station show a gain of 18 per cent. in weight of crop, in favor of subsoiling.

The time to plant will vary with locality and soil. Early planting gives largest crops. Good results have been obtained with plantings as late as June 13th at this Station, and June 15th at Rockyford, but four series of tests of ten experiments each, made in different sections of the State, show an average excess of 3.4 tons of beets for the plots planted from April 10th to 20th over similar plots planted from May 1st to 10th; 7.3 tons over those planted May 15th to 26th, and 12.4 tons over those planted between May 31st and June 10th.

If the soil is wet, very shallow planting will give good results, but the best results are generally obtained by planting from one inch to an inch and a half. Deeper planting is not advisable.

The distance between rows should be from 18 to 20 inches if in single rows. Mr. Watrous, in bulletin No. 21, recommends double rows 12 inches apart and 24 inches between rows. He claims that they are more easily irrigated. Prof. Cooke, in bulletin No. 57, recommends double rows 11 inches apart and 27 inches between rows.

Good crops have been raised by planting small quantities, three to five pounds of seed to the acre, but it is advisable to sow eighteen or twenty pounds to the acre. One of the most difficult things in beet growing in Colorado is to get a good stand.

In order to get a satisfactory germination of the seed, one or other of the following methods have given the best results: Either plant on freshly plowed soil with a good supply of moisture, or irrigate up.

Cultivation should begin as soon as the plants show the drills distinctly enough to be easily followed, when the surface should be thoroughly stirred to kill the young weeds. The young beet plants must not be covered.

Thinning may be begun as soon as the plants have gotten big enough, when they have four leaves, and may be extended over a period of two weeks. As the plants get larger, more care must be exercised on the part of the persons thinning, to avoid injury to the remaining plants.

The distance between the beets in the row may vary from six to ten inches—eight inches on an average gives a satisfactory crop. There is but little



difference in the weight of the crop when the beets stand six, eight or ten inches apart. At twelve inches apart the beets are apt to attain an undesirably large size.

The cultivation of the crop must be varied according to the character of the soil. Any instrument, the plow, the cultivator or special beet cultivating implement, which will put the soil in good condition without covering or otherwise injuring the plant, may be used. During the growing season the beets should be cultivated as soon after an irrigation as is practicable, to prevent encrusting of the surface, to level the ground, and to make a mulch of fine earth.

The number of irrigations necessary to raise a good crop will vary with the seasons. Mr. Watrous, in bulletin No. 21, says that in ordinary seasons, with an average rainfall of 13.89 inches, one irrigation during the growing season is sufficient to produce the best results. Some experiments made at Rockyford under Prof. Cooke gave the same result. The rainfall of that season was unusually heavy. If the water is at the command of the grower, the beets should be irrigated often enough to keep them growing continuously from the beginning of the season until the time of harvesting. Under this condition it pays to irrigate until late in the season. The difference in the halves of six plots, one half receiving no water after August 20th and the other receiving two irrigations after this date, was one seventh of the crop, in favor of the later irrigation.

It would be difficult to designate the best variety. The various strains of Kleinwanzlebener and Vilmorin probably take precedence. The Lion Brand, Mangold and Zehringen have given excellent results.

The plots grown under the direction of this Station or on the College Farm have given large yields. The average for ten counties of the State in 1898 is given as 19.9 tons. In 1899 the averages for eight series of twelve plots each ranged from 15.3 tons to 27.7 tons per acre. The writer's experience and observation would lead him to put the average crop for this section of the State at from 10 to 14 tons, ranging from six to thirty tons per acre.

The average percentage of sugar in the beet will probably be not far from 13 per cent., taken for a series of years; the range in the different crops will be between 10 and 20 per cent.

The average coefficient of purity will be between 79 and 81; in very favorable years possibly 82, in unfavorable years 77 or 78.

The date of ripening will vary with time of planting, soil, season and treatment of the crop. The earliest harvesting of workable beets of which I have record for Larimer county is September 15th; sugar 14.71 per cent., purity 80.4.

Our experience with transplanting beets is that the beets produced are of very ill shape, but may be rich in sugar, and yield well.

The application of a liberal dressing of well rotted manure will lower the percentage of sugar and coefficient of purity a little, but the crop will be increased more than enough to compensate for this.

Beets should not be permitted to dry out after being dug, as there is a loss of sugar.

Freezing does not destroy the sugar in beets, but freezing and thawing injures the beets for sugar making.

The beet is a vigorous feeder. A crop of 14 tons of beets would remove 300 pounds of mineral matter, about one half of which, or 150 pounds, is potash, and 25 pounds is phosphoric acid. If the tops are taken off the field there will be a still larger quantity of these substances removed. The fertility of the soil may be maintained by the application of well rotted manure, and by a judicious rotation of crops.

The trimmings of the beets make good fodder for cattle. The fresh tops, however, are apt to have a laxative effect.

The dry matter in the beet pulp is of rather more value, pound for pound, than the dry matter from the fresh beet. The pulp as obtained from the silo contains 90 to 92 per cent. of water. Slight fermentation is said to improve it.

We have grown beets carrying as high as 19 per cent. of sugar in soil rich in "alkali" salts. The average percentages of sugar for the crops of 1898 and 1899, grown in such soil, were 13.65 and 15.34 respectively. The coefficients of purity were 84.6 and 80.8.

As a rule medium sized beets are richer than either small or large beets. By medium sized beets is meant such as weigh from one to two pounds. Large beets, beets weighing from two to four or even many more pounds, may be as rich in sugar and have as high a coefficient of purity as beets of one pound or less, if grown under the same conditions. If not grown under the same conditions they cannot be compared. Even big beets grown under different conditions cannot be compared. Two beets, weighing respectively 2.88 and 2.90 pounds, grown in the same plot of ground within two hundred feet of one another, but under different conditions in regard to water supply, showed 10.45 per cent. sugar, 67.0 per cent. purity, and 16.06 per cent. sugar and 85.1 purity. Big beets *may be* rich beets, the size alone is not determinative.

It has been stated that one irrigation may, under certain seasonal conditions, suffice to produce the best results in regard to crop and quality of beets. Under other conditions of the season or soil, or both, more irrigations will be necessary. The condition of the crop will determine how late in the season irrigation may be profitably practiced. If the crop has already begun to ripen either a rainfall or an irrigation which causes a second growth will prove detrimental, but if the crop is in such condition that a second growth is not produced a late irrigation may do good.

A late over-irrigation offer does good, hastening the ripening and increasing the sugar. It has not been determined that it will uniformly produce this result. The character of the soil will probably modify the effect.

The higher parks of the State are not adapted to this culture, but good crops of rich beets have been grown in the San Luis valley at an altitude of rather more than seventy-five hundred feet.

The beet growing almost wholly under ground in this State, the loss in trimming is reduced to a minimum. Experiments indicate about 13 per cent. loss.

The amount of sugar in the crown of the beet, as it grows with us, is about one per cent. less than there is in the beet.

The cost of growing and harvesting an acre of beets will, of course, vary, but it is not far from thirty dollars per acre, exclusive of ground rent.

The growing of this crop will be more successful and the cost often materially lessened by the exercise of good judgment on the part of the cultivator. Specific rules for its culture, applicable to every case, cannot be laid down, and it must furthermore be remembered that even the very best rule can be so indifferently carried out that it may produce very poor results. No amount of experimentation can eliminate the difference between an intelligent, observing cultivator and one lacking these characteristics. Some land needs to be treated in a manner which would be wholly inapplicable in another case. Men who have tilled and irrigated their farm lands for years have learned how to treat each separate part of their farms. This knowledge is probably the secret of their success. No general statement regarding the culture of beets can be properly interpreted without taking these special facts into consideration.



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*Press Bulletins 1 to 11, 1899-1901.*—This series of bulletins was intended to spread information where promptness was requisite, or the matter not sufficient to justify a bulletin in the regular series. The editions have been small and the distribution made according to the subject matter. Some of the series were expected to be of ephemeral interest. The demand, however, has been continuous, and the editions of several having been exhausted, it is thought well to reprint the series and send to the regular mailing list.

BULLETIN No. 1, SEPTEMBER, 1899.

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## THE SUGAR-BEET CATERPILLAR.

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BY CLARENCE P. GILLETTE.

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The horde of caterpillars that have been devastating the beet fields during the past two weeks, between Palisade and Grand Junction, and that have occurred in small numbers from Grand Junction west towards Fruita, require the prompt attention of all interested in the success of the sugar beet culture in the Grand Valley, that the loss to this year's crop may be quickly checked and that severe losses for the coming year may be averted.

During the early part of the week (August 14th to 16th) the writer visited many beet fields in company with Mr. C. E. Mitchell and others, for the purpose of determining the nature and extent of the injuries, the length of time the attack is likely to continue, what remedies it will be best to apply, and other points of importance concerning the caterpillar.

The insect was found in the fields in all stages of development, except the egg. The caterpillars varied in size from those that did not exceed a sixteenth of an inch to the fully grown individuals that measured from an inch to an inch and a fourth in length. A large proportion were half grown or more, and many had changed already to the chrysalis or pupa state, just beneath the surface of the ground.

The fact that there are still many small worms makes it certain that the attack will continue to some extent to near the end of the present month (August). A quantity of the chrysalids were placed in suitable receptacles, and from them several moths, which are the adult insect, have appeared at this writing. The females are found to be heavily laden with immature eggs, and it is highly probable that within a few days these eggs will be deposited on or about the beets for a succeeding brood of worms. It is greatly to be hoped that the moths now hatching are only belated individuals of the second brood and that another full brood will not appear this summer. However this may be, not a day should be lost in beginning the work of destroying the



caterpillars now upon the beets. If the present brood is allowed to mature, it means a greatly increased number of caterpillars to contend with next year. It is with insects as with plants. The greater the number allowed to mature this year, the greater will be the quantity of seeds sown, and the larger will be next year's crop. The old adage, "A stitch in time saves nine," is more than doubly true when dealing with the destruction of insect life.

The closest watch should be kept during the next two or three weeks for the appearance of small worms. If none seem to be present, look carefully among the small and tender leaves at the base of the large ones, where they may be found.

#### REMEDIES.

A moderate number of friendly insects were found about the beets. These were lady-beetles, Aphis-lions and ground-beetles, all of which were probably preying to some extent upon the small caterpillars. Birds were very scarce in the beet fields; the crow seemed to be doing more than any others of the feathered tribe to destroy the caterpillars. It is plainly evident that the natural enemies are far too few to be of much service at present in keeping this insect within proper bounds. Artificial measures must be adopted to save a good partial crop of sugar beets over the eastern portion of the plantations about Grand Junction this year, and without these measures the crop over the whole valley may be largely a failure another year.

The caterpillars can be destroyed. The writer used both Paris green and kerosene emulsion, with satisfactory results, while at Grand Junction. The emulsion is more expensive and needs to be applied very thoroughly to give good results. The caterpillars should be thoroughly wet with it. This remedy would be specially useful on those fields where the caterpillars are very abundant and of large size and where the tops of the beets have been nearly or quite devoured. The chief benefit from destroying these caterpillars will be to lessen the number of the next brood.

By closely watching for the first appearance of the caterpillars when they are small, and then promptly and thoroughly treating the beets with Paris green or other arsenical poison, it is believed that the pest can be quite easily kept in check.

The poisons may be applied in a watery spray in the proportion of a pound of poison to 100 gallons of water.

Apply with force in a fine spray, and be thorough, but do not continue the spray in one place until the drops run together and carry the poison with them off the leaves. Where small patches are to be treated, a very simple method is to mix one pound of Paris green with about 20 pounds of common flour, and apply by dusting the mixture over the plants. This is readily done by placing a quantity of the poisoned flour in a small cheese cloth sack, which is held in the hand and shaken over the plants as the operator walks down the row of beets. This application can be best made when there is no wind and when there is a dew or rain upon the leaves to make the poison and flour stick.

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No. 2, APRIL, 1900.

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## **COLORADO SUNSHINE.**

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BY L. G. CARPENTER.

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The important effect of sunshine on plants, their growth and development, their aromatic oils, the color of their flowers, and the quality and color of their fruit, is well known. That it has an equal influence on the spirits and health of man, is also well recognized. In general it has a beneficial influence on useful plants, while destructive to injurious ones, as molds, fungi, and bacteria. It is one of the most potent germicides. Most diseases cannot spread in the presence of sunshine.

The following charts showing the sunshine day by day, throughout two years, are of more than passing interest, both from an agricultural and a sanitary standpoint. The record is made continuously at the Experiment Station.

The full lines show the sunshine. The breaks in the lines show when the sunshine was interrupted by clouds passing over the sun. The diagrams show at just what hours the sun shone on each day of these two years. Attention is called to the few days without some sunshine. May was the rainy month in 1898.

The record for 1897 is on one-half the scale of that of 1898.



# DAILY SUNSHINE CHART

FORT COLLINS, COLO.

JAN-JUN., 1898

Interference of Trees

SUNRISE

9 A.M.

12 M.

3 P.M.

SUNSET

HOUR SCALE.

JAN.

FEB.

MAR.

APR.

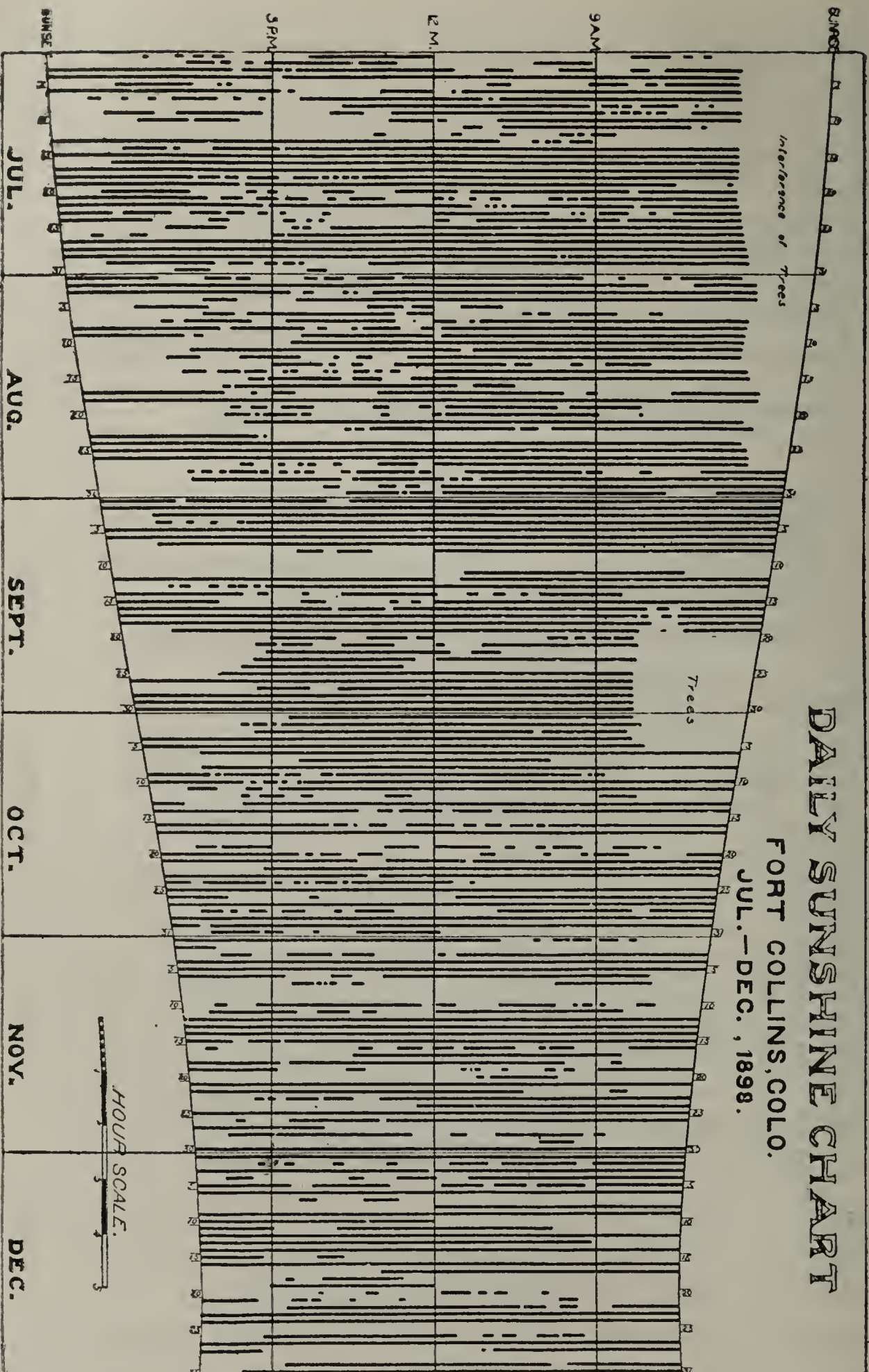
MAY

JUNE

# DAILY SUNSHINE CHART

FORT COLLINS, COLO.

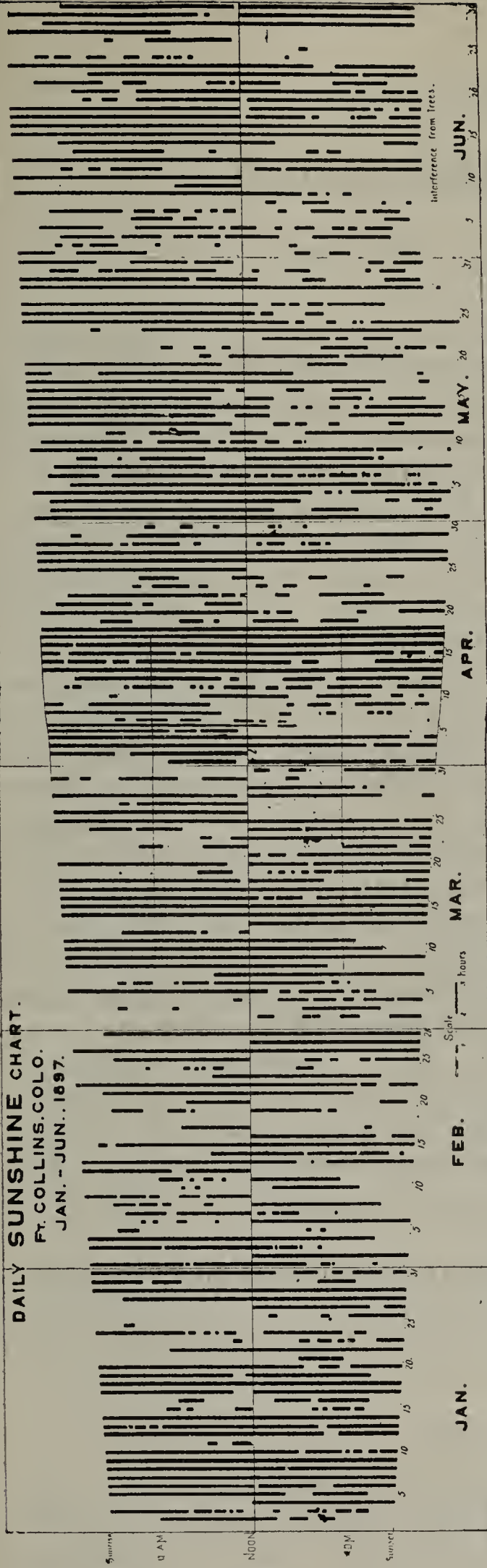
JUL.—DEC., 1898.





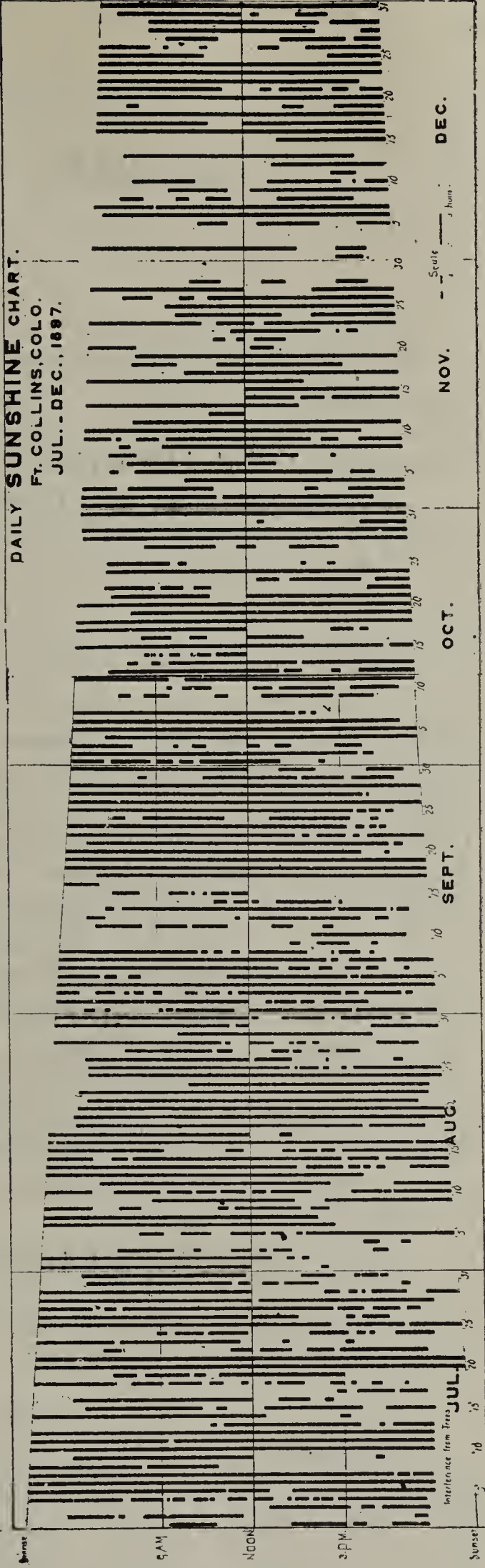
DAILY SUNSHINE CHART.

FT. COLLINS, COLO.  
JAN. - JUN., 1897.



DAILY SUNSHINE CHART.

FT. COLLINS, COLO.  
JUL. - DEC., 1897.



## THE BEET ARMY-WORM.

BY CLARENCE P. GILLETTE.

The caterpillar which did so much injury to sugar beets in the vicinity of Grand Junction last year will doubtless appear again this summer. While the insect has long been known to entomologists, last year was the first that it has ever been reported doing serious harm to any crop.

While the life habits of the insect have never been studied, it seems probable, from what the writer could learn of it last summer and fall, that it has two broods in the course of a year. The caterpillars that were so abundant during August last year entered the ground and then appeared again as moths in September. There were few enemies to destroy the caterpillars and the moths hatched in enormous numbers. These moths, like house-flies and mosquitos, seek every available place of protection from winter's storm and cold that they may live (hibernate) until spring. When vegetation starts the moths, laden with eggs, go in search of beets or other plants furnishing suitable food, to deposit their eggs and thus provide for an early brood of worms. If ten per cent. of the fall brood of moths survived the winter, there is serious danger that beets will fare worse this summer than they did last, unless growers are early on their guard to make thorough and timely application of effectual remedies. Just here let me warn all against experimenting with new or patent remedies which some friend or vendor may think entirely satisfactory. Use such remedies very cautiously and sparingly at first, or do not use them at all.

From what could be gathered last summer, it seems that there was a first brood of caterpillars at about the time for thinning the beets, which, in some cases, destroyed most of the plants after thinning.

### REMEDIES.

Experiments tried last summer proved that the common poisons, Paris green, London purple, and white arsenic, will destroy the caterpillars if well distributed upon the beets. These poisons may be applied dry or in water. If the caterpillars appear upon the beets while the



latter are small, I believe the best method of application is to mix one part by weight of Paris green or London purple with twenty parts of common flour, and then dust the mixture over the plants before sunrise in the morning. In this strength a light dusting will be sufficient. The early application is recommended, because the leaves have then a slight amount of moisture upon them, which helps to hold the flour and poison. Just after the leaves are moistened by a shower is also a good time to make the application.

To apply the poison, make a small cheesecloth sack about five inches in diameter and ten inches deep. Fill it with the mixture of poison and flour and walk along a row of plants shaking the sack over them. This can be done quite rapidly when one has learned how, is economical of poison, and does not require wheelbarrow or wagon to carry pump and tank.

When the plants become large, as in case of treatment for the second brood, it will probably be better to use a barrel or tank and spray pump.

If a spray is used, apply either Paris green or London purple in the proportion of a pound to 100 gallons of water and add two pounds of fresh lime for each pound of poison. The lime should be slaked and strained through a cloth to take out lumps. Then use a nozzle that throws a fine spray, and do not continue the application in any place long enough so that the drops sprayed upon the leaves will run together and flow off, carrying the poison with them.

If white arsenic is used, prepare according to the following directions:

Put two pounds of white arsenic and eight pounds of sal soda together in a dish and boil for twenty minutes in two gallons of water, and keep as a concentrated solution. *It is extremely poisonous and should be placed at once where there is no possibility that children or domestic animals can get it. Also, label it "poison" in large letters.*

Then, in each 40 gallons of water, first slake four pounds of lime and then add slowly one quart of the concentrated solution while the whole is being stirred. The mixture is then ready for application, as in the case of Paris green. The lime should be strained through a cloth to take out the lumps.

I am advising the use of these poisons somewhat stronger than is common, but the experience of last year makes it seem advisable to do so.

Growers should keep the closest watch of their beets this year, in order not to let the caterpillars get the start of them. I hope to be notified of any appearance of these worms or other injurious insects promptly, and shall be glad to do all in my power to aid those who are anxious to save their crops from the attacks of such pests.

No. 4, JUNE, 1900.

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## THE CANTALOUPE BLIGHT.

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BY H. H. GRIFFIN,

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Rocky Ford, Colorado, has long been famous for its cantaloupes. Until of late the industry has moved along at a rapid pace, little disturbed by insects or plant diseases. The blight, or rust, was first noticed on a few patches in 1896. There was an increase of the disease in 1897, more especially on the same fields, but its spread was not sufficient to cause much alarm. There was a vast extension of the disease in 1899 and the severity was much greater. The disease seemed to spread from a few well defined centres and grew less with distance from these centres. Many points in the Arkansas Valley report no injury. All evidence shows that the disease is not caused by any particular soil conditions, mode of irrigation, or peculiarity of climate.

The station began to investigate the question in 1898. Prof. Crandall, in 1899, pronounced the trouble due to a fungus, a new species named by Ellis and Everhart "*Macrosporium cucumerium*."

Seed taken from diseased melons was planted in 1899 to see if the disease was communicated by the seed. Three rows, each 250 feet long, were planted May 12th. The middle row was sprayed with Bordeaux mixture to test its efficacy as a preventative, or, should the disease appear, for its control. Sprayings were given to the middle row June 22nd, June 30th, July 22nd, July 31st and August 11th. At the time of the first spraying there was no appearance of the blight, but at the time of the second spraying it was noted that "something on the leaves that looked like blight" had appeared. Previous to the 19th of June the weather had been very dry, so that if any infection had been present it is not probable that its spread would have been rapid enough to become apparent. After this moisture was plentiful; seven inches of rain fell in July; 5.14 inches in the week commencing July 14th. These rains submerged the vines and could not fail to wash off the spray. At the third spraying the blight was strongly in evidence. In August 2.22 inches of rain fell and dews were prevalent. A decided benefit was derived from the sprayings made after the 22nd of July. The sprayed vines held up comparatively well, and



the fruit was of good quality. On the unsprayed vines the fruit ripened prematurely; they were insipid in taste, and it could be detected from which vines they were picked. The sprayed vines remained green and in a growing condition for two or three weeks after the others had succumbed. The plants grown from diseased seed did not seem to be more susceptible than those grown from seed from healthy vines.

Other experiments were inaugurated in the latter part of July on a more extensive scale. Both the Bordeaux mixture and an ammoniacal copper carbonate solution were used on different vines at each place. The first spraying with the Bordeaux mixture was given July 27th and the last August 18th. The carbonate was first used August 4th and the last spraying was made August 18th.

The test was made on seven rows, each 275 feet long, the vines that were sprayed remaining in good condition fully ten days after the others were gone. The melons ripened slower, in better condition, and were of uniformly good quality.

The results from the carbonate were not so pronounced as from the Bordeaux mixture. The results from the above work were so promising that it was tested on a still more extensive scale. About  $\frac{1}{8}$  of an acre of melons belonging to Senator Swink were sprayed. About one acre was sprayed for Mr. John Deweese, and one and three-fourth acres for Mr. C. S. Fenlason. Only one application was made at these places. These sprayings were done late in the season, when the blight was spreading rapidly. These melons were surrounded by others that were blighting badly.

The work confirmed the result of the other trials. Mr. Fenlason sold 300 crates of good melons from his sprayed field.

The virtue of the spraying lies largely in the ability of the melons to ripen properly, *i. e.*, to perfect the quality; the benefit is not alone to the vine.

It took 22 pounds of bluestone to spray the vines at Mr. Fenlason's, which were very large. The estimated cost was \$6.75 per acre. Had the work been done earlier the cost would have been much less.

#### APPEARANCE OF THE DISEASE.

The cantaloupe blight is caused by a true parasitic fungus. To the casual observer the first appearance is a large number of small brown spots upon the leaves in the

center of the hill. If the younger leaves are examined, it will be seen when the fungus is at work some time before the brown spots make their appearance. It can be seen when the leaf tissue has been eaten away, and when the injured tissue dies the brown appearance occurs. These brown spots grow larger as the fungus kills the tissue, until they become so numerous as to envelop the whole leaf; it appears as though struck by frost. It is surprising how quickly the spray will prevent the enlargement of these spots upon the leaf. At the time spraying is required the melon vine is making quite rapid growth, which necessitates spraying at intervals in order to cover the new growths.

#### HOW THE ACTION IS PERFORMED.

It can be readily seen that if some material is put upon the leaves that will kill the fungus, without injuring the host plant, the desired action is performed.

No fear need be felt that the bees will be poisoned. A number of hives stood near one of the fields treated, but no dead bees were found nor could it be seen that any injury resulted to them.

From the work of this season, we can advise that two or three spraying be given should the weather conditions prove favorable for the spread of the disease. If a dry season occurs perhaps the disease will not develop to any injurious extent.

From our present knowledge we should say that the first spraying should be done about the middle of July, followed every ten days until two or more are given, depending upon the weather. It would be well to follow the first rains of July with a spray.

Directions for making Bordeaux Mixture for use upon cantaloupes:

Dissolve 6 lbs of bluestone.

Slack 4 lbs. of fresh lime.

When the lime has become cool strain off the milk, adding it to the bluestone. Add water until there are 40 gallons.



No. 5, JULY, 1900.

## THE RUSSIAN THISTLE AS FORAGE.

BY J. E. PAYNE,

In many localities, the Russian thistle threatens to take possession of the land, in spite of all efforts of public-spirited people to keep it in check.

In neighborhoods where it has taken possession of the land, it seems best to ask—Can it be used for the benefit of the people whose land it has invaded?

The value of the Russian thistle has never been tested by a feeding experiment at any Experiment Station so far as we know, but the Minnesota Station has analysed the plants in various stages of growth. The following, copied from the Experiment Station Record, page 553, Vol. 6, gives the substance of Bulletin No. 34 of the Minnesota Experiment Station:

“When young the thistle is claimed to have a high food value, especially for sheep, which, some claim, are attracted to it merely on account of the salt which it contains. The chemical analysis shows a large percentage of ash material, amounting to nearly one-fifth of the dry weight of the plant. This is a serious objection to its use as a fodder plant, on account of the alkaline nature of the mineral matter present. One favorable point, as shown by analysis, is the large amount of nitrogenous matter present, being as much as there is in clover or rape. Before the development of the thorns, there is not much fibre present; at this time the plant is more valuable as a food than when mature. When the plant is ripe, the fibre and mineral matter make up half its composition, and although rich in nitrogenous matter, the former elements greatly reduce its feeding value

“The ash analysis shows that the weed has strong foraging powers, there being large amounts of potash and lime taken up by the plant. The draft which the plant makes upon the sodium in the soil is a benefit to alkali lands. The amount of sodium present varies greatly with conditions, showing that the plant is able to adapt itself to the alkaline conditions of the soil. From the time the thorns are out until the plant matures it takes up a large amount of sodium from the soil, and only small amounts of other materials, hence it makes the heaviest draft upon its soil while in an immature state, after which it takes but little essential plant food.”

The following testimony concerning the use of Russian thistles as a food for stock has been gathered from men who have had more or less experience in feeding it:

“Cattle eat Russian thistles, but they are poor feed.”

CHAS. HACKENBERGER,  
Burlington, Colo.

"Cattle will eat Russian thistles in large quantities. They physic cattle."

THOMAS SEAMAN,  
Wallet, Colo.

"Cattle eat Russian thistles. They seem to do well on them."

ELMER BROWN,  
Wallet, Colo.

"I am feeding my bulls, which I keep up, Russian thistle hay. Consider it good feed when cut before the thorns harden."

SAMUEL P. SHAW,  
Lamborn, Kansas.

"During the winter of 1899-1900, I fed a part of my cattle millet, and the remainder, about 40 head, Russian thistle hay. Those fed Russian thistles wintered fully as well as those fed millet. Fed none except during storms. Fed Russian thistles to those that were the best rustlers."

LEO THOMAN,  
Burlington, Colo.

"In June, 1895, my cows fed on young Russian thistles. I never made better butter nor more of it than I did that month."

A. C. WILLS,  
Lamborn, Kansas.

"My sheep eat Russian thistles, both green and dry. I think a patch of Russian thistles worth as much, for sheep feed, as the same area in grass."

WM. LANG,  
Cheyenne Wells, Colo.

"When I first began farming here, when wheat failed I had no feed for stock. Now, when wheat fails, Russian thistles take possession of the ground. I cut these and winter my cattle on them."

JOSEPH RUBY,  
Thurman, Colo.

The investigation has not been carried far enough to warrant us in recommending the Russian thistle as a hay plant when there is plenty of other forage. But the above testimony convinces us that those whose land is occupied by the thistles should cut some and try them as a feed for stock.



No. 6, DECEMBER, 1900.

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## A SO-CALLED BLIGHT CURE.

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BY CARL H. POTTER,

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The "Woodbury Blight Cure" as its name implies, is a proprietary article that has recently been placed on the market. This "cure" is guaranteed to be a certain remedy for the blight of apple and pear trees if used as directed, and a destroyer of insect pests as well. Two mixtures are sold by the company controlling the cure, a body wash and a summer spray. The claims for the remedies and the directions for their use, as set forth by the company, are as follows: \*

"The body wash should be used at least once during the season, preferably early in the spring on account of sun scald, but of immense benefit any time in the year.

"The summer spray should be used at least three times during the season for the cure of the blight and the destruction of insect pests. It should be used after, or during, every severe electrical storm for an insurance against the twig blight.

"Spray the first time when the trees begin 'o leaf, again from the middle to the last of July. Follow these directions carefully, and we will guarantee a cure for blight and the practical destruction of the codling moth and other injurious insects. The spray is beneficial and will promote a strong, healthy growth in all plant life, more especially on roses and vines. It will destroy slugs and green flies in the green-house."

On account of the fact that a large sale of such cure had been made, and that many inquiries had come to the Station, it seemed proper for a trial to be made.

June 29, 1898, a number of bearing apple trees in the Station orchards were selected and prepared for trial. Four distinct series or lots of trees were treated, while the others, as similar as it was possible to select them, were wholly untreated. These entered the test merely as checks with which to compare the trees that were treated. All of the trees to which the remedies were applied were recorded as class "A," while the untreated, or check trees, were class "C."

The different series of trees comprised summer, fall, and winter apples, and varied from very slight affection of the twigs to quite severe cases of blight, in which many of the smaller limbs were entirely diseased, the blight even forming large and more or less concentric patches on the

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\* From printed directions provided by the company.

larger limbs about the bases of the smaller ones. The trunks were not very badly affected by blight, yet there was plenty present for a test. Those trunks that were rough, whether in class "A" or class "C," were thoroughly scraped before treatment.

On the afternoon of June 29th the trunks and the lower portions of the limbs, to a height of about four feet from the ground, of the trees of class "A" were treated to an application of Woodbury's "wash," the material being applied with a stiff paint brush. About one quart of the mixture was used for each tree.

The following afternoon, June 30th, the same trees were thoroughly sprayed with the "spray mixture." The mixture was used double strength, as the directions recommended where an early spraying had not been given. The material was thoroughly stirred and then diluted to the strength of  $\frac{4}{5}$  of a quart of "wash" to  $4\frac{4}{5}$  gallons of water. Five gallons of this diluted mixture were used on each tree, the services of one man being constantly required to agitate the liquid in the box of the spraying pump. Blighted parts received especial attention.

August 13th all of the trees in class "A" were sprayed as before, except that the spray or "cure" was used as diluted in the proportion of one part of spray to 49 parts of water. November 15th the trunks of all the trees in class "A" were washed as before.

April 18, 1899, the trunks were again painted with the wash, a very thorough job being done. The trees were entirely dormant.

April 21st. Trees sprayed as per directions. Still dormant.

July 19th. Trees again sprayed as per directions.

This completed the application of the remedies to the trees. They had been used nearly two seasons, and were carefully and conscientiously applied. Frequent and careful observations of the trees were made, not only during the two seasons named, but extending through the season just closed. *We have not been able to detect, in any way, the slightest benefit to the trees as result of the use of these materials.*

Concerning the value of the spray as an insecticide, Prof. Gillette makes the following statement:

"I have tes'ed the 'Woodbury Blight Cure,' summer spray, upon both leaf-eating and sap-sucking insects, and in no case did it seem to have any injurious effect upon the insects treated. Leaves thoroughly wet with the solution were eaten by insects which afterward matured in perfect condition."



No. 7, FEBRUARY, 1901.

## THE SEEPAGE MEASUREMENTS OF THE EXPERIMENT STATION.

BY L. G. CARPENTER.

One of the effects due to irrigation that is noticed in all countries is the seepage water which returns from irrigation and enters the streams. This is so much that streams may be drained dry and, within a short distance, again have an appreciable quantity of water.

At the suggestion of Hon. B. S. LaGrange, President of The State Board of Agriculture, and at that time Water Commissioner of District No. 3, a measurement was made in 1885 of the Poudre River by the State Engineer's office, and two others were made in 1889 and 1890. In 1891 the Experiment Station took up the matter to investigate in detail the amount and the laws of the increase. Such measurements have since been carried on annually on the whole length of streams in the State, from their exit from the mountains to the State line. These include the Cache a la Poudre, the South Platte, the Big and Little Thompson, the St. Vrain and Left Hand creeks, Boulder and South Boulder, Clear Creek, Bear Creek, the Arkansas from the mountains above Canon City to the Kansas State line, the Rio Grande from near Creede to the New Mexico line, and the Conejos. Of these, measurements have have been made for four years on the Arkansas and for five years on the Rio Grande, and the others for varying times.

It has been the intention to extend these measurements to other parts of the State as soon as time and means permitted. During the past year, 1900, the measurements were begun on the Western Slope, and were made on the Uncompahgre River from Ouray to Delta. These measurements have required every foot of the streams to be passed over, every headgate visited, every stream that leaves the river, as well as those which flow into it, to be measured. This has required the traveling over, in detail, of very nearly one thousand miles of river during the past season, and from six to eight hundred miles for each of the past four years. In all, some five thousand miles, at least, of river measurements have been made.

A report, giving the results of investigations up to that date, was issued in Bulletin 33. This discussed the relation of the seepage to the area irrigated and to the amount of water applied, as well as the rapidity of the flow of the waters under ground, and showed that the value of this source of water supply amounted to several hundreds of thousands of dollars.

This bulletin has been very widely quoted. The more recent measurements have been given in the annual reports of the Experiment Station, and in the report of the State Engineer. Bulletins discussing these measurements, and comparing them, will soon be issued by the Experiment Station.

In addition to these measurements the Experiment Station has also made hundreds of miles of measurements on canals to determine the amount of loss by seepage from canals, the means of preventing the seepage, and the means of protecting lands from such damage. It is studying the character of the water used in irrigation, the amount of water used in irrigation, and other phases of the irrigation question.



No. 8, APRIL, 1901.

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## POTATO FAILURES.

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BY W. PADDOCK AND F. M. ROLFS.

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The Experiment Station has received a number of inquiries from potato growers in various sections of the State in regard to the failure of the potato crop in certain seasons. These failures seem difficult to explain, since there is little blight in evidence, and they occur with experienced growers as well as with beginners, and on soil that would seem to be in a good state of fertility. In some instances the vines are said to have made a luxuriant growth and remained green until late in the season, but when digging time came the tubers were found to be much under size. In other instances a large growth of vines were found to have set an abnormal number of tubers which failed to develop.

At first thought it would seem that some of the elements necessary to the growth of the potato plants were lacking in the soil, and this may be true in some instances, but it will not explain all the failures. Certain fungi or plant diseases have been found to be abundant on the potatoes in various parts of the State, which may have something to do in producing these conditions. One of these diseases has been known in America as a potato disease\* less than a year, though it has undoubtedly been present in our potato field for a long time. In Europe it is considered to be one of the most destructive potato diseases. The fungus does not confine its attacks to potatoes alone, but is found in a great variety of plants, including alfalfa, clover and sugar beets.

The disease attacks the potato plant just below ground, cutting off free communication between foliage and tubers. In extreme cases the plants may be killed, and much of the so-called late blight or early ripening of the vines may be due to this disease.

The fungus lives over winter on the stems and tubers of the potato, and on various other plants. The fungus adheres to the tubers in the form of dark patches which resemble bits of soil, and which vary in size from that of a mere speck

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\* Dugger and Stewart, Bulletin 186, p. 17, N. Y. State Experiment Station, and Bulletin 186, p. 63, N. Y. Cornell Experiment Station.

to areas a half inch or more in diameter. The fungus does not injure the potatoes directly, but it detracts from the appearance of the tubers when offered for sale. But the important point is, that when infected potatoes are planted the fungus is planted with them, and thus the disease is propagated year after year.

The fact that the fungus attacks the roots of alfalfa complicates the treatment, since alfalfa is commonly used in the rotation of crops. If potatoes free from the disease are planted on land which has been in alfalfa within two years, the chances are that the crop will be affected, providing there has been any of the fungus on the alfalfa plants. The length of time that the fungus will live in the soil is not known. German authorities state that it will persist for at least three years. Neither has the kind of crop which should be grown on infected land to starve the fungus been definitely determined; however, it is not known to attack our common cereal crops.

It is too early to recommend a line of treatment to overcome the above conditions, since the cause of the trouble is not positively known, but potato growers who have been troubled in this way may find it profitable to take certain sanitary precautions. Such measures consist in planting potatoes, on land on which potatoes, beets, alfalfa or clover have not been grown for at least three years, and potatoes that are free from disease should be used for planting. If there is reason to suspect that the seed potatoes are infected with fungi, they may be treated with corrosive sublimate or formaline, as is recommended for potato scab.

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#### Formulæ for Treating Diseased Seed Potatoes. \*

Corrosive sublimate.....1 ounce  
Water..... 8 gallons

Dissolve the corrosive sublimate in one gallon of hot water, then dilute with seven gallons of water. Allow the potatoes to soak one and one-half hours. When dry they may be cut and planted, though it has been found to be a good practice to treat the potatoes a week or more before planting, since the treatment may retard germination if done just before planting.

Corrosive sublimate is a deadly poison, and it should be used in wooden or earthen vessels, since it corrodes metals.

Formaline.....8 ounces  
Water.....15 gallons

Soak the potatoes two hours in this solution, preferably but a short time before planting. This solution is somewhat more expensive than the corrosive sublimate treatment but has the advantage of being non-poisonous, and it may be used in any kind of a vessel.

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\* Jones, L. R., and Edson, A. W., Vt. Sta. Bul., 85.



No. 9, APRIL, 1901.

## SUNSHINE FOR 1900.

BY L. G. CARPENTER.

While the pleasure afforded by a sunny day is of common experience, the value of sunshine as an element in the climate, whether from the standpoint of health or spirits or of agriculture, is not often given the importance it deserves. Until recently no attempt has been made to record the amount or intensity, even in those places specially interested in agricultural meteorology.

A certain amount of sunlight is recognized as a necessity for plant growth, for without it the development will be absent or unhealthy. With an increase in sunlight there is almost always an improvement in quality, and in the amount of essential oils; or in special qualities, as in sweetness, and an increase in the color of fruits and flowers. There is a decrease in the prevalence of certain diseases with direct sunshine. It has been known from time immemorial that dirt and darkness were conditions favorable for disease, while cleanliness and light were unfavorable. Molds and fungi, and the invisible but perhaps more important bacteria, do not thrive in sunshine. Even in diffused light few bacteria develop, and direct sunshine is destructive to most, if not to all, injurious forms within a short time. Sunshine and the drying action of the air are unfavorable to such forms of life, and are Nature's chief disinfectants.

A sunny climate or a sunny home is thus more apt to give the conditions for such physical health as are necessary to permit of sunny dispositions.

The charts show the amount of sunshine at Fort Collins for 1900, as recorded by an automatic photographic recorder and then transferred to the diagram.

A line is given to each day. The black line shows the duration of the sunshine and the hours at which it shone. When broken or absent, clouds are indicated. The longer the break, the longer the duration of the cloudiness. The diagram therefore shows the exact hours at which the sun shone during the year. It is noticeable that the forenoon had more sunshine than the afternoon, and that the winter months had comparatively little cloudiness. The relative amounts vary in different seasons, as a comparison with the charts in Press Bulletin No. 2 of 1900 will show.

# DAILY SUNSHINE CHART

FORT COLLINS, COLO.

1900

From Trees

||

|||

Interference

JAN.

FEB.

MAR.

APR.

MAY.

JUN.

HOUR SCALE

SUNRISE

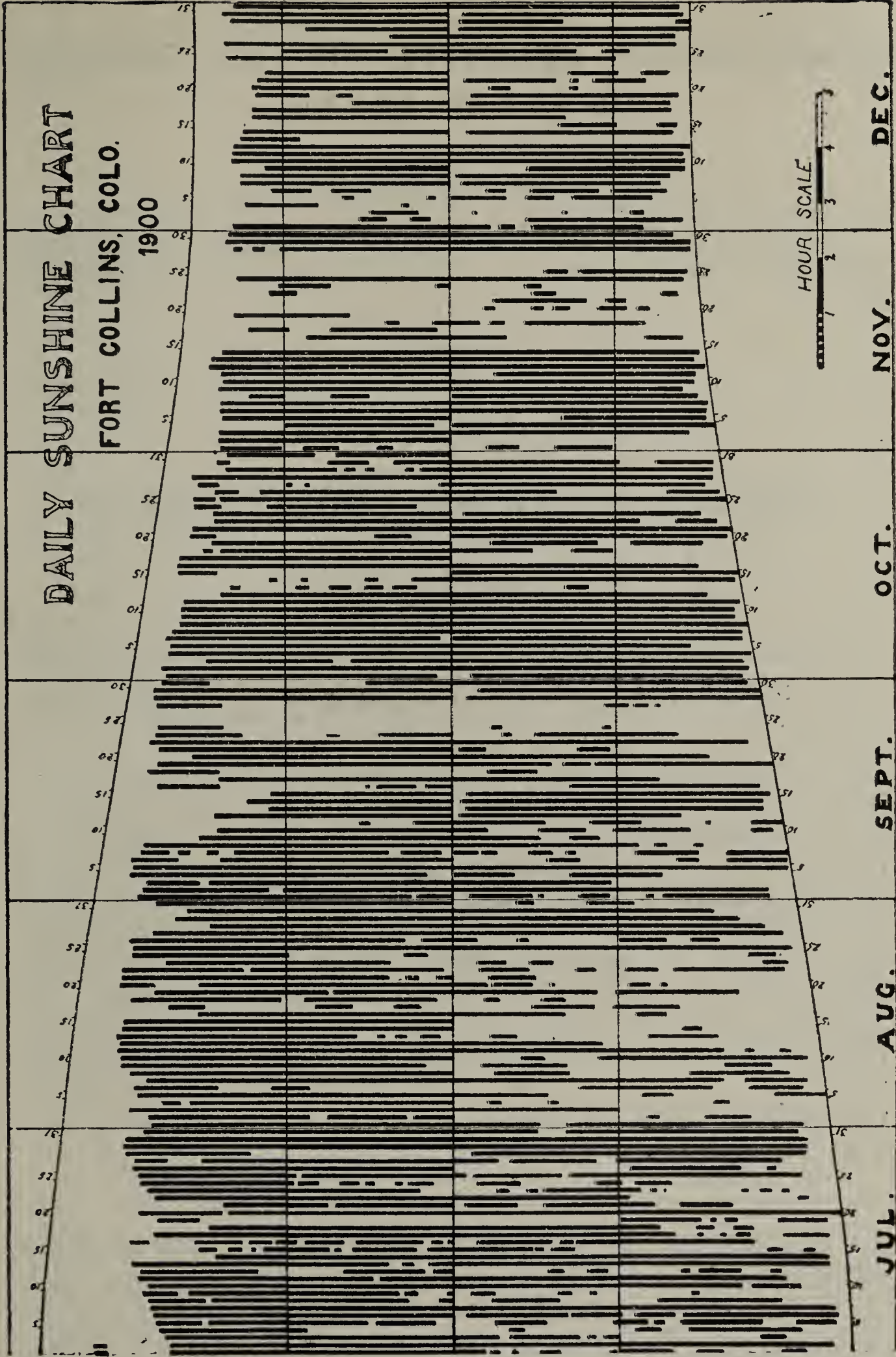
9 A.M.

12 M.

3 P.M.

SUNSET





No. 10, APRIL, 1901.

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## CONCLUSIONS RELATIVE TO THE CULTURE OF SUGAR BEETS. \*

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BY W. P. HEADDEN.

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\* This appears as a Summary of Bulletin 63.† A Resume of the Publications of the Colorado Agricultural Experiment Station, and is not here reprinted.

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No. 11, APRIL, 1901.

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## HOW TO FIGHT THE CODLING MOTH.

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BY CLARENCE P. GILLETTE.

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Many orchardists spray for the codling moth and still grow very wormy apples. The writer knows of an orchard near the Experiment Station that was sprayed with an arsenical mixture three times last summer and in which fully 80 per cent. of the fruit was wormy at the time of picking in September. Another orchard in the same neighborhood was sprayed twice and had less than 2 per cent. of wormy fruit at picking time. What made the difference? Why is it that one man sprays his orchard and has very little wormy fruit and his neighbor, who also sprays, has nearly all of his apples wormy? This is a question often asked and frequently difficult to answer satisfactorily. That a reason exists for the different results there can be no doubt. The object of this paper is to give the best directions that we can at present for the successful treatment of this insect. Perhaps it will explain to some why they have not met with better success in the past.

### WHEN TO SPRAY.

No date can be fixed upon, yet spraying *must be done at the right time* if the best results are to be obtained. The *right time* is immediately after the blossoms fall and before the calces of the forming apples close. If there are belated blossoms on the trees after the great mass of bloom has



fallen, do not wait for them if some of the calces are closing. If the trees do not all bloom nearly together, spray the early blooming trees first and then in a few days spray the others. Repeat the application in one week, or, at the latest, ten days.

#### HOW TO SPRAY.

Be thorough with the work. It will take more time and material, but if spraying for this insect will pay at all it will pay best to do the work well. Use a nozzle that throws a medium fine spray, not a mist, and direct it so that the liquid will be thrown *into* every blossom or calx. A misty spray will not carry as well into the blossoms. To make a thorough application, it will be necessary to direct the spray from, at least, two sides of the tree, and if the tree is large, it will be almost necessary to apply from all four sides. In many orchards the trees are so closely set, so large, and poorly pruned, that it is impossible to make a thoroughly good treatment for the destruction of codling moth larvæ.

The one who directs the nozzle for the spraying will find it a great advantage to be elevated as high as the bed of a wagon box at least. If the trees are large, it will be well to use a step-ladder or a dry goods box in the wagon to elevate him still more.

#### NUMBER OF APPLICATIONS.

Orchardists differ widely in opinion as to the number of applications that should be made. Some, noticing that the worms are most abundant late in the summer, think that spraying should be continued throughout the season of growth and report excellent results from spraying five or six or more times. However, it is the opinion of those who have tested the matter most thoroughly at the various experiment stations of the country that it does not pay to spray more than twice, if the two applications are properly made at the best time.

#### POISON TO USE.

Here again opinions differ. Probably Paris green is as effectual as any if well applied and if the liquid is kept thoroughly agitated during the spraying. Scheele's green would probably be as effectual as Paris green, is cheaper, and remains in suspension in water better. London purple and arsenate of lime are readily kept in suspension in water but are slower in their action than the above mentioned

poisons, and probably less effectual in their death-dealing power. They have the advantage of being very cheap. Arsenate of lead is kept in suspension without difficulty and is remarkable for its adhesive quality and its entire harmlessness to foliage unless used in great excess. It kills slowly and its value for the destruction of the codling moth has not been very definitely determined.

#### PREPARATION OF THE POISONS.

*Paris green, Scheele's green and London purple* may be used in the proportion of 1 pound to 160 gallons of water. It is best to mix the poison in a small amount of water first and then in the full amount for which it was prepared. For each pound of poison used, add to the water one or two pounds of freshly slaked lime. This will lessen the liability of the poison to burn foliage.

*Arsenate of lime*, by the Kedzie formula is prepared as follows: "Boil two pounds of white arsenic and eight pounds of salsoda for fifteen minutes in two gallons of water. Put into a jug and label 'poison'. When ready to spray, slake two pounds of lime and stir into 40 gallons of water, adding a pint of mixture from the jug."

If this formula is followed, be sure to use a full measure of fresh lump lime, otherwise some of the arsenic will be left in solution in the water and will kill the foliage.

A somewhat simpler method of preparing arsenate of lime is to boil together for three-quarters of an hour 1 pound of white arsenic, 2 pounds fresh lime, 1 gallon water. Use one quart of this to an ordinary barrel of water (about 40 gallons).

If a stock solution of this poison is kept, be sure to label it plainly "poison," and it would be well to put in some kind of coloring matter besides.

If arsenate of lead is employed, use not less than one and one-half pounds to 50 gallons of water. Lime need not be added to this preparation.

If more than two applications are made, do not use the poisons in more than two-thirds of the above strengths after the second treatment.

#### OTHER REMEDIAL AND PREVENTIVE MEASURES.

*Bandages* of burlap or other cheap fabric placed about the trunks of the trees from the middle of June till September will collect large numbers of the larvæ which gather beneath them for the purpose of changing to the pupa and then



to the moth stage. If these bands are removed once in a week or ten days, quite a large percentage of the worms may be collected and destroyed. A bandage four inches wide and having two or three thicknesses of cloth is of good size and may be held in place by means of a single carpet tack thrust through the overlapping ends into the bark of the tree. A band thus held may be quickly taken off and replaced.

*Gathering and destroying fallen fruit*, either by hand or by means of hogs or sheep turned into the orchard, will help some to keep the codling moth in check, but most of the worms leave the apples before they fall. After apples have lain on the ground for three or four days almost no worms can be found in them.

*Protect cellar doors and windows* with screens wherever apples are kept so that moths hatching in the cellar cannot escape to the orchard.

*Clean culture* and the removal of all rubbish in and about the orchard will make it more difficult for the worms to find a suitable hiding place for the winter.

*Scraping the loose bark* from trunk and branches will also remove many safe hiding places for worms during winter.

No one should be discouraged because he does not meet with as complete success in the use of the above remedies as he had hoped the first year. He who persistently and intelligently uses them through a series of years will be almost certain of a degree of success that will convince him of their value.





Bulletin 65.

September, 1901

# The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

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## A SOIL STUDY.

PART III.

## THE SOIL.

—BY—

WILLIAM P. HEADDEN.

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PUBLISHED BY THE EXPERIMENT STATION  
Fort Collins, Colorado.  
1901.

# The Agricultural Experiment Station,

FORT COLLINS, COLORADO.

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# A SOIL STUDY:

## Part III. THE SOIL.

BY WILLIAM P. HEADDEN, A. M., PH. D.

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*[For convenience of reference the principal paragraphs are numbered, and a table of contents placed at the end of the bulletin.]*

§ 1. Bulletins 46 and 58 contain the results of our observations upon the effects of the mechanical condition, the "alkalis" contained in, and the general properties of this soil upon the crops grown on it. This bulletin forms the continuation of our study, and will treat of the soil itself. The preceding bulletins have treated of the crops; this will have nothing to do with them.

The crops grown were, with one exception, sugar beets. This soil, judged by the crops it has yielded, is abundantly rich in plant food. The crops obtained are more conclusive in regard to this point than the indications of the chemical analyses. In this case, however, the two methods of judging lead to the same conclusion, *i. e.*, that any failure of plants to grow is not due to a lack of fertility.

### REASONS FOR CHOOSING THIS PLOT OF GROUND.

§ 2. The choice of this particular piece of ground for study was determined by the fact that it was considered to be the most strongly alkalized plot to be found on the College Farm. It had been cultivated previously, but no crop was obtained. It was next set to forest trees, but the most of them died, only a very few surviving the first season, and the surviving plants were unhealthy. The roots of the young trees which were set out in the spring of 1896 were blackened by the soil, and did not seem to have grown at all. There is no reason to doubt but that this was due to the soil conditions, for the mortality among the plants varied with the soil in which they were set. In portions of this forestry plot, which included the plot made the subject of this study, the young trees lived well, whether they made trees or not. The soil and its condition, however, was quite different. This fact eliminates several questions, such as the condition and vitality of the young trees at

the time of setting, the manner of setting and their subsequent treatment. The failure of the forestry experiment in this portion of the plantation was quite certainly due to the soil. To be more specific, it was due either to the salts present in the soil, to the soil being so wet as to prevent a sufficiently free access of the atmosphere, or to some other unfavorable condition. The presumption was that such large quantities of salts as were evidently present were quite sufficient to prevent, by their direct action, the development of the plants without considering their effect upon the soil.

#### OUR ORIGINAL OBJECT EXTENDED.

§ 3. The primary object of the study was to determine, if possible, the effects of these salts upon certain crops, to see if their accumulation could be prevented or hindered by cropping, or even removed by cropping to sugar beets after they had accumulated to the extent of producing a decided alkalization of the soil. As we stated in Bulletin 46, the beet crop did not remove more soda salts from the soil under these conditions than under ordinary conditions, and it became necessary to extend our study in order to obtain an answer to our inquiry as to how we could ameliorate such conditions. The question assumed such shape that we found ourselves almost compelled to address ourselves to the study of the soil itself.

#### THE APPLICATION OF GYPSUM NOT ADVANTAGEOUS.

§ 4. There is a general impression entertained by some that the application of gypsum to our alkalized soils would mitigate the bad effects of these salts. This opinion has found some support from the results of its use in California. The cases are entirely different. We have not the conditions that the Californians have, and the benefits obtained by the application of gypsum in their case, will not appear in ours. The character of our "alkali" is such that we cannot expect any benefit from the use of gypsum. In our particular case its addition would be a waste of material and a loss of labor, the soil being already so full of this salt that it can easily be recognized as crystalline aggregates disseminated through the soil, often giving it a mottled appearance. The addition of more gypsum under such conditions would be utterly useless.

#### THE CHARACTER OF THE SOIL.

§ 5. The soil itself, as was stated in Bulletin 46, varies in its character from a loamy soil with a calcareous, clayey subsoil, to a fine alluvium resting upon a stratum of gravel, separated from it by a rather compact clay, but with no proper hard pan. The whole soil is very retentive of moisture, and it is difficult to determine whether there is any direct draining of the water from the alluvial soil above into the gravel stratum below or not. The configuration



of the surface would justify the assumption that there is no hydrostatic pressure upon the water in the gravel stratum ; at most it can scarcely be enough to force the water through the clay into the soil above. This would lead us to the surmise that the water in the gravel may be entirely different from the water in the overlying soil. Analyses made in the early part of our work corroborated this view.

#### DRAINAGE.

§ 6. The drainage of the area, of which the plot under observation forms a part, is into the Cache a la Poudre river, at a point about one and three quarters miles below the town of Fort Collins. There is at present an open ditch running through this swale for a considerable distance, and the College management has laid tile drains for a long distance, serving to extend the drainage system almost to the line of the College property. The lateral drains are laid with four inch tiles ; the main drains with six, eight and ten inch tiles. On the lower portion of the property there are two drains, laid with eight and ten inch tiles. These drains are parallel for a portion of their length and in part divergent.

§ 7. A study of the country shows that this swale was formerly the bed of a considerable stream formed by the union of streams issuing from the foothills through Spring, Dixon, Soldier and probably what is now the Poudre canon. This fact accounts for the strata of gravel and sand encountered in and along the margins of the swale.

The foundation of the Chemical Laboratory, situated on the north side of the swale, had to be put down to a depth of 20 feet on account of quicksands. At this depth, however, the workmen encountered a stratum of coarse gravel.

The fall from the plot of ground under observation to the Poudre river is about 150 feet, more rather than less. This old water course is now filled up. Ten or twelve years ago this plot of ground was very wet and boggy, the principal vegetation being cat-tails. This condition was undoubtedly due to the character of the soil, which, as I have stated, is very retentive of water.

#### ORIGIN OF THE SOIL.

§ 8. The source of this soil is evident and will not account for the alkali salts or its physical properties. The gravel, where there is any at all, is clearly granitic, and can not be the residue from the breaking down of the younger formations of the foothills and plains. The mechanical analysis of the soil shows that even the finest sand is granitic and has been derived from the mountains within the foothills, carried and deposited by the waters which at one time had this swale for their bed. The only evidence that any of the

soil material is of different origin is the occurrence, now and then, of a fragment of an impure limestone, which lies just outside the first hogback and belongs to the Fort Benton group or of sandstone belonging to the Juratrias. These fragments are quite rare and are the only definite proof that I have discovered that any portion of the soil has been derived from any other source than the granitic area of the mountains proper. The abundance of mica and red orthoclase in the coarser portions of the soil, and even in the silt, leaves no doubt but that this is the source of the material.

Some of the material may be the residue of strata belonging to formations of later or post cretaceous times, whose removal by waters, now represented by the Poudre river, has left some of this material. This is undoubtedly true of much of the plains soil, but probably only to a very limited extent of the soils of these old water courses.

#### SOURCE OF THE ALKALIES.

§ 9. The alkalies are not so easily traced. The explanation offered for the presence of alkalies in the soils of arid regions is as true here as elsewhere, but these general facts are not applicable in the explanation of the particular cases with which we meet in Colorado agriculture. It is a well known fact, one long since recognized, that the shales of several of the cretaceous groups contain a remarkable amount of these salts, designated by the general term alkali, including sodium, calcium, and magnesium as sulfates, carbonates, and chlorids.

#### GENERAL COMPOSITION OF THE ALKALIES.

§ 10. Analyses of incrustations from various parts of the State, and of waters from both ordinary and artesian wells, show the very general distribution of these salts. They also corroborate the observation of their presence in the shales and other rocks which, whatever may have been the origin of the salts, serve at the present time to furnish the alkalies to the waters percolating through them. The following figures, representing the general composition of the alkali, will serve to illustrate the general application of the assertion. An incrustation from the College Farm showed:

|                   |       |        |           |
|-------------------|-------|--------|-----------|
| Calcic sulfate    | ----- | 25.451 | per cent. |
| Magnesian sulfate | ----- | 19.798 | per cent. |
| Sodic sulfate     | ----- | 41.748 | per cent. |

The ground water from about five feet below the surface yielded an abundant residue, composed of:

|                   |       |        |           |
|-------------------|-------|--------|-----------|
| Calcic sulfate    | ----- | 35.648 | per cent. |
| Magnesian sulfate | ----- | 28.750 | per cent. |
| Sodic sulfate     | ----- | 11.393 | per cent. |



A surface well, 28 feet deep, yielded water giving a large residue, of which these salts formed 74 per cent., as follows :

|                        |        |           |
|------------------------|--------|-----------|
| Calcic sulfate.....    | 15.206 | per cent. |
| Magnesian sulfate ---- | 29.059 | per cent. |
| Sodic sulfate ----     | 29.865 | per cent. |

An artesian well, supposed to tap a water bearing Dakota sandstone and having a depth of 845 feet, furnished a water carrying 79 grains of total solids in each imperial gallon, of which 83 per cent. consisted of these salts, as follows :

|                        |        |           |
|------------------------|--------|-----------|
| Calcic sulfate.....    | 12.036 | per cent. |
| Magnesian sulfate ---- | 10.473 | per cent. |
| Sodic sulfate ----     | 60.758 | per cent. |

It is evident, not only from observation, but as is also indicated by such figures as these, that it is not at all necessary for the agriculturist to question in regard to the immediate source of the salts included under the general term alkali. They are so abundantly present in the rocks and waters, even in waters from considerable depths, that there is no need to seek further for their supply. The questions relative to their more remote origin and how it happens that the shales and even the sandstones are impregnated with these salts can be left to the geologist without serious inconvenience in studying the questions with which our agriculture has to deal. They are here, and in cases where the drainage of any larger area accumulates in a small basin, alkali salts will be brought together and under proper conditions will appear as an incrustation. This does not take place unless the water plane is at a less distance from the surface than that through which capillarity can raise the water in the particular soil. This was the case in the soil in question, the incrustations accumulating to a maximum thickness of upwards of one half inch. The incrustations being most marked in early summer, but also during the winter when the condition of the weather was favorable.

Relative to the origin of such quantities of sulfates in these rocks and soils, the possible supply is abundant, for throughout the mountain masses we find sulfids disseminated everywhere and we have an almost inexhaustible source of sulfuric acid for the formation of alkali in the gypsum which is so abundant in our Jurassic and other formations.

#### THIS STUDY LARGELY A MINERALOGICAL ONE.

§ 11. It is to be understood that throughout this bulletin the term soil is used sometimes to mean all of the factors conducing to make up the unit which is expressed by this term ; at others in a much narrower sense, meaning to include only a part of the same.

Most of our analyses, for instance, have to do with only one phase of the subject and that almost exclusively a mineralogical one which may practically be designated as a somewhat indefinite study of the decomposition products of feldspar, principally a red orthoclase. It may be a little humiliating at this juncture to make so uncomplimentary a statement concerning this part of our work, but it is scarcely more. This is very plainly suggested by the results of the mechanical analysis which, as already stated, shows this mineral to be the principal one from which the potash can be derived. The small amount of mica in the soil would, even if the mica were easily attacked and altered, contribute but a very small amount of potash or lime, it being very subordinate in quantity. The analyses of the separate parts of the soil as obtained in the mechanical analysis will be shown to suggest the same fact so forcibly that it amounts almost to absolute proof that in our samples we have to do with an altered feldspar.

#### THE EXPERIMENTS COVER TOO SHORT A PERIOD.

What the effect of growing three crops on this soil may have been is scarcely shown by so short a series of experiments; that is, the results are not large enough to be measured by the means at our command. Even if we should confine the effect to the clay this would still be true. This, however, cannot, as we will show, be justly done, for the feldspar certainly yields fresh quantities of potash to the soil. This mineral is so finely divided, or enough of it is, that even the rain water can and undoubtedly does take a perceptible quantity of this compound into solution.

#### POTASH IN FELDSPAR AVAILABLE.

§ 12. We shall show by direct experiment that the oat plant, for instance, can appropriate potash from this mineral when it is finely powdered, even in cases in which the mineral is perfectly fresh and the whole work of decomposition has to be done during the period of growth of the plant, perhaps by the roots of the plant itself. The theory of the formation of zeolitic minerals, to serve as the conveyors of the potash, etc., from the more stable minerals to the plant, cannot very well be appealed to, at least as necessary. My experiments do not show that zeolitic compounds are not formed, but they do show that if they are formed, their formation takes place so rapidly that perfectly fresh, but finely pulverized, feldspar becomes an available source of potash in the short period required for the growth of the oat plant. I do not mean to say that finely powdered feldspar will yield potash so rapidly that it will furnish a supply adequate to the production of a crop, but that it will furnish in the aggregate a very considerable quantity of this element. It is a well known fact that this mineral yields potash to water and it



was to be expected that growing plants might obtain some potash from this source, but my experiments show that this plant may perfect its growth, obtaining all of its potash from the pulverized feldspar.

§ 13. This fact is of great importance to our Western agriculture, especially to the agriculture of the eastern slope of the Rocky Mountains and eastward to the State line, as the irrigable lands are composed largely of granitic materials and consequently contain a more or less considerable quantity of feldspar, whose decomposition yields, slowly it may be, but a continuous supply of this very important compound. The partially altered mineral possibly presents a greater degree of resistance to further decomposition than the fresh mineral does to the first attack, but this will affect only the rate of the supply, for we know that this mineral eventually suffers complete decomposition. These soils, or mixtures of minerals, quartz, feldspar and mica, are well preserved because our climatic conditions have not been favorable to their decomposition, either directly or through the decay of organic matter. The rate of change under more favorable conditions, those of irrigation with an increase of vegetable matter, may be more rapid, but it will still be comparatively slow; not too slow, however, to make its results a factor in the supply of potash for our cereal crops.

§ 14. A question arises in this connection relative to the course which the decomposition of the feldspar takes, and whether an experiment with powdered feldspar is comparable with the conditions which prevail in the soil. There is no question but that they are not wholly so. The decomposition may go on either more rapidly or less rapidly in the soil than in the experiment with a mixture of sand and feldspar in boxes. Still the results are, in a measure, comparable. The soil contained from 16 to 28 per cent. of dust, the particles of which have a diameter of less than 0.01 millimeter, and while, as previously intimated, the original feldspar present may have already been so changed that its further decomposition may be somewhat slower than at some previous stage of its history, it has not been removed from all further action of the solutions in the soil, the plant roots and other agents.

In experimenting with the feldspar, the whole of it was reduced to powder, whose largest grains were less than one millimeter in diameter, and of which rather more than 33 per cent., by weight, consisted of particles of less than one quarter of a millimeter in diameter. The feldspar was pulverized to render it more readily attacked, and to reduce its particles to a size comparable with the size of the finer soil grains.

#### FELDSPAR A SOURCE OF HYDROUS SILICATES.

§ 15. The water in the soil also shows that such changes are

going on continuously, for they are constantly removing salts in solution, the supply of which is, in part at least, maintained by the decomposition of the constituent minerals of the soil. If there were no such supply of these salts, they ought to have diminished in quantity to a very small fraction of that which we now find. The formation and continuous presence of highly reactive, hydrous silicates within the soil may be accepted as established, but back of this, as well as of that of clay, whether kaolinitic or colloidal, are the decompositions of which these compounds are themselves but products. In the case of the soils in question, the original minerals whose changes have furnished the materials for these zeolitic compounds are preeminently the feldspars of the granites of the front range. Traces of igneous rocks are found, but their part in the formation of these soils is so subordinate that they may be neglected. That the ground waters, already rich in salts, participate in producing these changes is very probable. The uniform presence of potash salts in the ground water is presumably due in part to this fact. The elimination of potash from the soil in the form of nitre, potassic nitrate, will account for the presence of some, but not for the whole, of the potash present in the ground water. The presence of silicic acid in all of the water, amounting in some instances to about 2 per cent. of the total solids, is likewise suggestive of the decomposition of silicates, yielding, among other products, new silicates soluble in water. The silicic acid present in the water analyses, which will subsequently be given, was in solution either as hydrated silicic acid or in the form of soluble silicates.

A very striking instance of the presence of silicic acid in water came under my notice a few years ago. The water was a very excellent spring water, free from sediment, limpid, and had a temperature of 53° F. The silicic acid present amounted to 25 per cent. of the total solids held in solution. I do not know whence this silicic acid was derived, but most probably from the decomposition of some feldspar, as potash and soda were the next most abundant constituents of the residue obtained from the water. The chemical changes producing such a solution as this in a spring water are quite sufficient, even though they may be modified in many ways, to account for the silicic acid found in the residues obtained from ground waters.

#### SOME SALTS ARE FORMED IN THE SOIL.

§ 16. We cannot distinguish between the salts which have been dissolved out of adjacent localities and brought by the flowing waters into the area where it is found, and those which have been formed in the latter soil. In the former case they may contribute to bring about new changes, in the latter they will be products of the changes ordinarily going on in that soil, and aid in giving



distinctive properties to it. These would remain if the others should be eliminated.

§ 17. The relative amount of magnesian salts which are present in the ground waters before and after the soil has been cultivated, also before and after the application of manure, indicate that there is a series of reactions taking place which result in eliminating these salts as end products. The growing of crops, the cultivation and irrigation of the soil, also the application of manure, accelerate these changes. The readiness with which these reactions take place, especially if they be beneficial to the crop, must, to a considerable extent, be a measure of the soil's fertility.

#### THE BIOLOGY OF THE SOIL NOT STUDIED.

§ 18. The soil is not only the theater of a wide range of chemical reactions, some dependent upon and some independent of the living organisms present, but it is also the home of an abundant microscopic life, constituting a veritable world of itself.

§ 19. The biological conditions of the soil ought, in this study, to have been taken up with thoroughness, but it has been impossible. We will present the results obtained by such study as we have been able to devote to the soil in the following pages.

§ 20. The purely agricultural features of this study have already been given in Bulletins 46 and 58. These bulletins have treated exclusively of the crops grown on the soil, especially of the effects of the alkali on the growth and ripening of the plant, on the amount of ash constituents taken up, etc. In this bulletin we shall treat of the soil, and in a subsequent one of the ground waters, the irrigation water and its changes.

#### THE PHYSICAL CHARACTER OF THE SOIL.

§ 21. Beginning at the west end of the plot the soil is a light loam. This passes into a paludal soil rich in alkali, succeeded by a gravelly, clayey soil, which has resisted treatment to a greater extent than any other portion of the plot. The most eastern section of the plot is the lowest, the wettest, and, judging by the abundance of the salts which effloresce, the most strongly alkalized one. The extreme western section is the only one in which there is a subsoil within six feet of the surface. The character of the eastern most section was that of a very tenacious, alkalized clay, which, when moulded to a form and dried, became exceedingly hard. It was a most unpromising soil to attempt to do anything with. The plot has a slope to the eastward of about four feet in 600. There is a stratum of coarse sand and gravel underlying the whole of the plot at a depth of about six feet. The surface is fairly even, with a slight depression running diagonally from near the southwest corner to the north side, a little west of the centre.

PREPARATION OF THE SAMPLES.

§ 22. Six samples of this soil were taken in the spring of 1897, before it was plowed for the planting. These samples were taken with care to obtain samples representing the soil. Sections 8''×8''×10'' were cut out and prepared for analysis. These sections were dried, all lumps being broken by hand from day to day as they became dry enough to be rubbed to pieces in this manner. When drier, and too hard to be so manipulated, they were rubbed in an iron mortar, the mortar being filled so full that pulverization did not take place. In order to be able to study the rock fragments still remaining in the samples, they were passed through sieves from one quarter inch to one twenty-fifth inch mesh. All that passed through the one twenty-fifth inch or one millimeter mesh, was preserved as the sample of fine earth. The coarser portions, six in number, were thoroughly washed and their weight and character determined. The samples were designated by the letters A, B, C, D, E and F. The successive parts are designated by the subscript figures 1, 2, 3, etc.

SAMPLE A.

§ 23. This sample was taken from the east end of the plot, 40 feet east of well A, the worst section of the plot. The sample was divided into the following parts:

| <i>Parts.</i>        | <i>Mesher to the Square Inch.</i> | <i>Character of the Fragments.</i>                             | <i>Per Cent.</i> |
|----------------------|-----------------------------------|----------------------------------------------------------------|------------------|
| A <sub>1</sub> ..... | 4....                             | Quartz, granite, mica, limestone, feldspar.....                | 0.68             |
| A <sub>2</sub> ..... | 9....                             | Quartz, granite, brown sandstone, limestone, feldspar .....    | 1.17             |
| A <sub>3</sub> ..... | 36....                            | Quartz, granite, mica, oxid of iron, limestone, feldspar ..... | 2.19             |
| A <sub>4</sub> ..... | 144....                           | Quartz, granite, iron oxid, limestone, feldspar.....           | 4.35             |
| A <sub>5</sub> ..... | 196....                           | Quartz, mica, feldspar .....                                   | 1.92             |
| A <sub>6</sub> ..... | 625....                           | Quartz, mica, iron oxid and feldspar.....                      | 6.31             |
|                      |                                   | Fine earth.....                                                | 83.38            |

SAMPLE B.

§ 24. This sample was taken 50 feet west and two feet north of well A. This sample is from the edge of the gravelly, clay knoll, on the north side of the plot, and east of the centre:

| <i>Parts.</i>        | <i>Mesher to the Square Inch.</i> | <i>Character of the Fragments.</i>                              | <i>Per Cent.</i> |
|----------------------|-----------------------------------|-----------------------------------------------------------------|------------------|
| B <sub>1</sub> ..... | 4....                             | Quartz, brown sandstone, mica, feldspar .....                   | 4.54             |
| B <sub>2</sub> ..... | 9....                             | Quartz, brown and red sandstone, mica, feldspar..               | 3.40             |
| B <sub>3</sub> ..... | 36....                            | Quartz, brown and red sandstone, iron oxid, feldspar .....      | 6.39             |
| B <sub>4</sub> ..... | 144....                           | Quartz, brown and red sandstone, iron oxid, mica, feldspar..... | 6.83             |
| B <sub>5</sub> ..... | 196....                           | Quartz, mica and feldspar .....                                 | 3.14             |
| B <sub>6</sub> ..... | 625....                           | Quartz, mica, feldspar.....                                     | 11.95            |
|                      |                                   | Fine earth.....                                                 | 63.75            |

SAMPLE C.

§ 25. This sample was taken 45 feet west and three feet north



of well B. This sample is from the eastern edge of the depression running diagonally across the plot and western edge of gravelly knoll.

| <i>Parts.</i>        | <i>Mesher to<br/>the Square Inch.</i> | <i>Character of the Fragments.</i>                                                      | <i>Per Cent.</i> |
|----------------------|---------------------------------------|-----------------------------------------------------------------------------------------|------------------|
| C <sub>1</sub> ..... | 4....                                 | Quartz, granite, feldspar .....                                                         | 13.77            |
| C <sub>2</sub> ..... | 9....                                 | Quartz, granite, limestone, iron oxid, feldspar, red<br>and brown sandstone, mica ..... | 6.63             |
| C <sub>3</sub> ..... | 36....                                | Quartz, granite, limestone, sandstone, mica, feld-<br>spar .....                        | 9.78             |
| C <sub>4</sub> ..... | 144....                               | Quartz, mica, limestone, sandstone, feldspar.....                                       | 7.53             |
| C <sub>5</sub> ..... | 196....                               | Quartz, mica, limestone, feldspar.....                                                  | 2.63             |
| C <sub>6</sub> ..... | 625....                               | Quartz, mica, feldspar.....                                                             | 9.08             |
|                      |                                       | Fine earth.....                                                                         | 50.58            |

## SAMPLE D.

§ 26. Sample taken 25 feet west and three feet north of well C. This sample represents the low portion of the west half of the plot. It is quite wet and strongly alkalized.

| <i>Parts.</i>        | <i>Mesher to<br/>the Square Inch.</i> | <i>Character of the Fragments.</i>                             | <i>Per Cent.</i> |
|----------------------|---------------------------------------|----------------------------------------------------------------|------------------|
| D <sub>1</sub> ..... | 4....                                 | Quartz, granite, feldspar .....                                | 1.50             |
| D <sub>2</sub> ..... | 9....                                 | Quartz, red and brown sandstone, limestone, feld-<br>spar..... | 0.67             |
| D <sub>3</sub> ..... | 36....                                | Quartz, granite, sandstone, limestone, feldspar..              | 1.86             |
| D <sub>4</sub> ..... | 144....                               | Quartz, sandstone, limestone, iron oxid, feldspar..            | 2.80             |
| D <sub>5</sub> ..... | 196....                               | Quartz, limestone, mica, feldspar.....                         | 2.08             |
| D <sub>6</sub> ..... | 625....                               | Quartz, mica, feldspar.....                                    | 8.81             |
|                      |                                       | Fine earth.....                                                | 82.27            |

## SAMPLE E.

§ 27. Sample taken three feet west and three feet north of well D. This sample represents the western end of the plot.

| <i>Parts.</i>        | <i>Mesher to<br/>the Square Inch.</i> | <i>Character of the Fragments.</i>                                  | <i>Per Cent.</i> |
|----------------------|---------------------------------------|---------------------------------------------------------------------|------------------|
| E <sub>1</sub> ..... | 4....                                 | Quartz, granite, feldspar .....                                     | 0.71             |
| E <sub>2</sub> ..... | 9....                                 | Quartz, granite, feldspar.....                                      | 0.29             |
| E <sub>3</sub> ..... | 36....                                | Quartz, granite, limestone, sandstone, iron oxid,<br>feldspar ..... | 1.25             |
| E <sub>4</sub> ..... | 144....                               | Quartz, mica, limestone, iron oxid, feldspar.....                   | 3.38             |
| E <sub>5</sub> ..... | 196....                               | Quartz, mica, limestone, feldspar .....                             | 2.99             |
| E <sub>6</sub> ..... | 625....                               | Quartz, mica, feldspar.....                                         | 11.37            |
|                      |                                       | Fine earth .....                                                    | 80.01            |

## SAMPLE F.

§ 28. This sample is the subsoil corresponding to sample E.

| <i>Parts.</i>        | <i>Mesher to<br/>the Square Inch.</i> | <i>Character of the Fragments.</i> | <i>Per Cent.</i> |
|----------------------|---------------------------------------|------------------------------------|------------------|
| F <sub>1</sub> ..... | 4                                     |                                    | 0.00             |
| F <sub>2</sub> ..... | 9                                     |                                    | 0.00             |
| F <sub>3</sub> ..... | 36....                                | Quartz, limestone, feldspar.....   | 0.03             |
| F <sub>4</sub> ..... | 144....                               | Quartz, limestone, feldspar.....   | 1.58             |
| F <sub>5</sub> ..... | 196....                               | Quartz, limestone, feldspar.....   | 1.84             |
| F <sub>6</sub> ..... | 625....                               | Quartz, limestone, feldspar.....   | 9.34             |
|                      |                                       | Fine earth.....                    | 87.21            |

MECHANICAL ANALYSIS OF THE " FINE EARTH."

§ 29. The beaker elutriation of the fine earth gave the following results:

TABLE I.—MECHANICAL ANALYSIS OF THE FINE EARTH.

| SAMPLE.                                    | Hygroscopic<br>Moisture. | Temperature<br>of Absorption. | Water<br>Capacity. | Coarse Sand.<br>1.0 to 0.5 mm. | Medium Sand.<br>0.5 to 0.25 mm. | Fine Sand.<br>0.25 to 0.05 mm. | Silt.<br>0.05 to 0.01 mm. | Dust.<br>Less than<br>0.001 mm. | Clay<br>by<br>Difference. | Ignition. |
|--------------------------------------------|--------------------------|-------------------------------|--------------------|--------------------------------|---------------------------------|--------------------------------|---------------------------|---------------------------------|---------------------------|-----------|
| Soil A.....                                | 6.40                     | 15°                           | 51.05              | 4.459                          | 5.392                           | 26.078                         | 19.527                    | 27.878                          | 8.314                     | 8.351     |
| Soil B.....                                | 4.50                     | 15°                           | 36.50              | 8.114                          | 10.147                          | 35.593                         | 12.386                    | 23.653                          | 4.582                     | 5.543     |
| Soil C.....                                | 4.20                     | 15°                           | 44.22              | 7.318                          | 6.940                           | 20.518                         | 20.828                    | 27.633                          | 7.876                     | 8.887     |
| Soil D.....                                | 5.90                     | 15°                           | 40.54              | 6.254                          | 7.197                           | 25.894                         | 24.748                    | 21.704                          | 6.013                     | 8.190     |
| Soil E.....                                | 3.40                     | 15°                           | 36.84              | 7.070                          | 9.227                           | 29.947                         | 25.573                    | 16.642                          | 3.534                     | 8.007     |
| Soil F.....                                | 3.50                     | 15°                           | 42.34              | 6.380                          | 7.409                           | 23.736                         | 30.604                    | 19.488                          | 5.552                     | 7.673     |
| Loess Soil. Weld Co..                      | .....                    | .....                         | .....              | 1.172                          | 3.737                           | 45.707                         | 27.721                    | 10.565                          | 5.217                     | 5.881     |
| Loess Soil. }<br>Larimer Co. }             | .....                    | .....                         | .....              | 0.965                          | 2.073                           | 24.451                         | 49.714                    | 11.797                          | 4.567                     | 6.433     |
| Red Soil. }<br>Clay Soil. }<br>Red Beds. } | .....                    | .....                         | .....              | 4.411                          | 11.872                          | 27.943                         | 31.592                    | 13.793                          | 4.600                     | 5.789     |

THE MINERALOGICAL CHARACTER AND SOURCE OF THE SOIL PARTICLES.

§ 30. The sand grains in the different samples consisted of quartz, feldspar and some flakes of mica. The quartz grains show plainly the deposition of oxid of iron upon their surfaces, in checks and depressions in the grains. The deportment of the sand, and more particularly the still coarser portions, warns us that we cannot conclude that the sand particles owe their origin to the red beds, because of their color after ignition, for there is enough organic matter coating the grains to cause blackening upon heating, and this may account for the presence of the iron oxid which becomes evident upon igniting the sands. There is nothing distinctive enough, so far as I have observed, about the sand grains to justify one in asserting that they did or did not come from the juratrias, or Dakota sandstones, or are directly due to the breaking up of the granites. The presence of so large an amount of feldspar and mica, neither of which is present in the sandstones of these formations in such quantity, is strong proof that practically the whole mass is derived directly from the rock masses of the mountains which lie immediately west of us, and consists of granites, gneisses and mica schists.

§ 31. While I believe myself justified in making the state-



ment that the most of the rock material of this soil came directly from the mountain masses in geologically recent times, I am fully aware that the disintegration of the red sandstones, and to a less extent the conglomerates of the red beds, could give rise to a very similar mixture of rock fragments. The following facts show this plainly. A sandstone belonging to the upper part of the Upper Wyoming, of loose texture and easily disintegrated by soaking and judicious rubbing, without any grinding up of its particles, gave me the following mechanical analysis:

Sand grains having a diameter greater than two millimeters, 1.40 per cent.; greater than one millimeter, 26.80 per cent.; less than one millimeter, 62.70 per cent.; cementing material, oxid of iron, calcic carbonate, etc., 9.10 per cent. The sand grains were principally quartz, but there were some grains of feldspar and a few flakes of mica. In regard to the fineness of the particles, it will be noticed that practically 63 per cent. of the mass of the sandstone was as fine as that division of the soil designated "fine earth," and that this percentage is as great or greater than that of the fine earth in two of our soil samples. The alkalies in this sandstone were determined and found to amount to 1.30 per cent. of the sandstone; potash constituting 1 per cent., and soda three tenths of 1 per cent. The cementing material, mostly calcic carbonate and oxid of iron, contained a small amount of these constituents, potash 0.025 per cent., soda 0.053 per cent., calculated on the sandstone, not on the weight of the cementing matter. The alkalies were also determined in a sandstone from the Lower Wyoming, and found to equal 2.563 per cent. of the sandstone; potash 0.924 per cent., soda 1.639 per cent. The potash in each of these cases amounts to about 1 per cent., and is contained almost wholly in the sand grains, among which, especially among the larger ones, feldspar grains are easily recognizable. These sandstones do give rise to a soil whose elutriation would yield a mixture of sand grains somewhat similar to that with which we have to do in this study. The characteristics of the soil formed by the disintegration of these sandstones are so markedly different from those of the one we are considering, that they are not even suggested as the possible source of the material, except by the most thorough washing of the soil formed from them.

§ 32. The statements relative to the mineralogical character of the different classes of soil particles are applicable to all of the soils which I have analyzed or examined with care, whether close to the mountains or as far east as the State line, excepting the soils of the valley lying between the hogback formed by the Dakota sandstone and the mountains proper. This area, corresponding to the outcrop of the red beds, is not wholly covered by this granitic soil. There are doubtlessly some sections where the surface soil is derived from younger formations, the particles of which have not

been transported from the mountains by the streams or waters which have given the country its present contour, but are disintegration products of formations composed of material similar to that brought from the mountains by the streams of later times.

The particles of more than 0.5 millimeters diameter are for the most part rounded, but this is not the case with those less than .25 millimeters, nearly all of which are sharply angular.

§ 33. It may appear to many, especially to such as have an acquaintance with the occurrences of loess and other formations of the plains, the mineralogical constituents of which are often identical with those given for these soils, that the latter, like the former, may be the product of other disintegrations than that of the granites of the Colorado range. There is nothing in their composition to preclude their having been derived from some other source. Their geographical distribution makes it probable that material similar to this composing our soils has been derived from other mountains than those lying near to us. It seems reasonable, however, to assume that the near and very extended range has furnished essentially all of the material going to make up these soils. There may be a doubt entertained that the quartz, feldspar and mica given in the preceding table were derived from the present mountains, but there can be no question regarding the source of the fragments of red and brown sandstones, or of the impure limestone; these are the products of the disintegration of the red beds and of the Fort Benton limestone.

#### SOIL COMPARED WITH LOESSIAL SOIL.

§ 34. There is given in the table of mechanical analyses, one of a loessial soil from Weld county. This soil, according to the mechanical analysis, has a very different composition from the soils given above. It is characterized by a high percentage of fine sand and low percentages of dust and clay, but mineralogically the sand and coarser parts are the same as in the other soils, *i. e.*, quartz, feldspar and mica. The mica, though still subordinate in quantity, is more abundant in the loessial soil than in the others. It seems to be a general rule that the farther back from the river we get, or higher up on the plains, the greater is the percentage of fine sand present in the soil.

§ 35. I have not attempted to determine the ratio between the grains of feldspar and quartz in these soils, but others have determined this ratio in the loess, for which the approximate determination is given as: Quartz, 40 per cent.; feldspar, 50 per cent.; other constituents, 10 per cent.\* The minerals making up the other 10 per cent. were, in the case of the Weld county loessial soil,

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\* Emmons' Geology of the Denver Basin in Colorado, p. 262.



mica, magnetic oxid of iron, etc. I have not determined, by actual count, the grains of quartz and feldspar, but my judgment is that there is more quartz in the sands that I have separated from these soils than is indicated by the percentage given in the analysis quoted, viz., 40 per cent. It is to be expected that the mechanical composition of soils will vary from place to place, and yet the table shows a greater agreement than we would expect; the sample of loessial soil from Weld county and of loess from Larimer county being the only ones which show wide deviations in the percentage of any class of soil particles. Not only the mineralogical, but also the chemical examination of these soils, indicate a rather uniform composition, though the samples were taken from widely separated localities. By chemical analysis is here meant the analysis of the whole mass, a mass analysis, and not a soil analysis as it is made for agricultural purposes.

§ 36. Dr. S. F. Emmons, writing of the loess in the "Geology of the Denver Basin in Colorado," says that it contains in all cases a large proportion of sand, separable by washing, whose grains are usually under a millimeter, but rarely less than a tenth of a millimeter in diameter. The mechanical analyses of the loessial soils show 43 and 64 per cent. of the mass to have a diameter of less than five one hundredths of a millimeter. The mechanical analysis of this soil shows 47.40 per cent. of material, the clay not included, whose grains have a diameter of less than one tenth of a millimeter, and which differ from the coarser portions only in the degree of their comminution. The loessial soils given agree in having high percentages of fine sand and silt, and lower percentages of dust and clay than ordinary soils; but our results do not agree with Dr. Emmons' observation that the grains of sand in loess are rarely less than one tenth of a millimeter in diameter.

#### SIMILARITY OF THE PARTICLES AND COMPOSITION OF SOILS.

§ 37. The fine sands are, in every case, much more angular than the coarser, due to the manner in which the water has effected their transportation, the larger having been rounded by rolling or by attrition while in suspension. The loessial soils show this characteristic as markedly as the other soils examined. There is so great a similarity in the mineralogical composition of our soils, though they vary in appearance, that it is a matter of some surprise that they should differ so extremely in properties. The chemical analysis of the soils, mass analysis, does not change this phase of the matter at all. The following analyses of samples taken from rather widely separated localities, may serve to illustrate this:

TABLE II.—MASS ANALYSES OF SOME SOILS.

|                                   | Prairie Soil, South of<br>Agricultural Hall.<br>Surface. | Soil A.<br>Taken 10" deep. | Loessial Soil,<br>Weld County.<br>21½" deep. | Loessial Soil,<br>Larimer County.<br>6 ft. from top. | Loess.<br>Cheyenne, Wyo.* |
|-----------------------------------|----------------------------------------------------------|----------------------------|----------------------------------------------|------------------------------------------------------|---------------------------|
| Silicic Acid.....                 | 69.356                                                   | 64.745                     | 72.550                                       | 67.836                                               | 67.100                    |
| Sulfuric Acid.....                | 0.041                                                    | 0.827                      | 0.023                                        | 0.025                                                | .....                     |
| Carbonic Acid.....                | 0.016                                                    | 1.208                      | 0.368                                        | 0.888                                                | 3.670                     |
| Chlorin .....                     | 0.006                                                    | 0.014                      | Trace.                                       | 0.022                                                | ... ..                    |
| Phosphoric Acid.....              | 0.466                                                    | 0.112                      | 0.331                                        | 0.411                                                | 0.110                     |
| Potash .....                      | 2.248                                                    | 2.295                      | 2.479                                        | 2.497                                                | 2.680                     |
| Soda .....                        | 1.215                                                    | 1.184                      | 1.498                                        | 1.311                                                | 1.420                     |
| Lime .....                        | 1.645                                                    | 2.789                      | 1.075                                        | 2.481                                                | 5.880                     |
| Magnesia .....                    | 1.412                                                    | 1.819                      | 1.245                                        | 1.740                                                | 1.240                     |
| Ferrous Oxid.....                 |                                                          |                            |                                              |                                                      | 0.310                     |
| Ferric Oxid.....                  | 5.424                                                    | 4.475                      | 4.420                                        | 5.255                                                | 2.520                     |
| Aluminic Oxid .....               | 11.338                                                   | 11.717                     | 10.754                                       | 11.418                                               | 10.260                    |
| Manganic Oxid (br).....           | 0.160                                                    | 0.200                      | 0.239                                        | 0.109                                                | .....                     |
| Moisture at 110° C.....           | 2.981                                                    | 3.296                      | 2.595                                        | 3.569                                                | .....                     |
| Ignition.....                     | 4.044                                                    | 5.402                      | 2.311                                        | 2.287                                                | 5.090                     |
| Sum.....                          | 100.352                                                  | 100.080                    | 99.888                                       | 99.849                                               | 100.280                   |
| Oxygen Equivalent to Chlorin..... | 0.001                                                    | 0.003                      | .....                                        | 0.005                                                | .....                     |
| Total.....                        | 100.351                                                  | 100.077                    | 99.888                                       | 99.844                                               | 100.280                   |

\* Analysis by Eakin's Geology of the Denver Basin in Colorado, p. 263.

I have chosen the sample of loess from Cheyenne because this is probably more nearly comparable to mine than any other at my disposal, and the locality is nearer by thirty miles than that from which the next nearest sample was taken. The sample marked loess from Larimer county was taken at a point about seven miles from the place where the sample soil A was taken. The most marked variations in the composition of these samples are, the sulfuric acid of the soil A, the carbonic acid and lime of the loess from Cheyenne. The sulfuric acid in the soil was probably present as calcic sulfate or sodic sulfate, forming a part of the "alkali" present in the soil. The carbonic acid and lime in the Cheyenne loess was doubtlessly present as calcic carbonate. This is of common occurrence in this formation; is very variable, and is not essential. With these exceptions, the causes of which are usually discernible without the aid of chemical analysis, or even a magnifying glass, these soils agree as closely as samples taken within a few feet of one another might



agree, and suggest a common origin for wide areas of our surface soils.

The alkalies are lower than one would expect, judging from the number of feldspar particles which are present, and the ratio of the soda to the potash is high, as the feldspar recognizable is very predominantly orthoclase. The silicic acid is lower than the apparently large number of quartz grains present would suggest. The orthoclase contains, in round numbers, 66 per cent. of silicic acid, while the average percentage of this acid in these soils is 68.6 per cent., which seems lower than the macroscopic examination suggests.

#### PORTIONS OF FINE EARTH EXAMINED.

§ 38. The loess from Cheyenne was not examined further, nor was the loessial soil from this county, but the soil A was. The fine sand, with particles from 0.25 to 0.05 millimeter in diameter, the silt, the dust and the clay were each analyzed with the following results:

TABLE III.—ANALYSES OF PORTIONS OF "FINE EARTH" OF SOIL A. SAMPLE TAKEN TEN INCHES DEEP.

|                               | <i>Fine Sand.</i> | <i>Silt.</i> | <i>Dust.</i> | <i>Clay.</i> |
|-------------------------------|-------------------|--------------|--------------|--------------|
| Silicic Acid.....             | 82.024            | 69.247       | 58.204       | 40.389       |
| Sulfuric Acid.....            | 0.017             | 0.014        | 0.100        | 7.060        |
| Potassic Oxid.....            | 1.914             | 2.711        | 3.166        | 3.000        |
| Sodic Oxid.....               | 1.926             | 1.851        | 1.323        | 3.134        |
| Ferric Oxid.....              | 3.383             | 5.425        | 9.109        | 7.113        |
| Aluminic Oxid.....            | 6.737             | 13.018       | 19.078       | 14.607       |
| Calcic Oxid.....              | 1.746             | 1.488        | 1.480        | 6.059        |
| Magnesian Oxid.....           | 0.777             | 1.519        | 2.648        | 3.982        |
| Manganic Oxid (brown).....    | 0.150             | 0.250        | 0.190        | 0.168        |
| Moisture and Organic Matter.. | 0.750             | 4.118        | 3.980        | 14.668       |
| Total.....                    | 99.424            | 99.631       | 99.278       | 100.180      |

The coarser parts of the soil were not analyzed, for the reasons that they are comparatively small in quantity and, on account of the large size of their particles, are not subject to those actions which liberate plant food to any considerable extent. It might have been better for a favorable presentation of results had we analyzed them, but there was so little to be gained that we did not deem it worth the work. This table shows a very decided difference in the composition of the parts separated by washing the soil. We have no basis of comparison with the loess and other soils. The series stands alone, but the results that it exhibits are so pronounced and so similar to what we would expect that we have little hesitancy in accepting it as proven that there is an accumulation of the potash in the finer portions of the soil, and a diminution of the silicic acid.

#### PROBABLE COURSE OF CHEMICAL CHANGES IN SOIL MASS.

§ 39. We have here probably a rough presentation of the

course of the chemical changes which take place in the transformation of a mass of rock fragments into true soil. The decomposable minerals, feldspar and mica, very subordinate in this case, are so acted upon that new minerals, having less silica but more alumina and possibly alkaline earths, are formed. The high percentage of lime in the analysis of the clay is almost certainly due to an admixture of gypsum. It is scarcely possible, owing to the manner of preparation, that the higher percentage of magnesian oxides can be attributed to a similar cause. In regard to the potash, which is even higher in the dust than in the clay, though the experienced analyst will be inclined to consider them the same, there may be a question as to the manner in which it is present. This arises from the knowledge of facts obtained from other experiments and not from the analyses. The testimony of the latter is, and it is in perfect harmony with what we know of the deportment of soil masses, that in the extremely small particles of the soil there is a tendency toward enrichment in potash. The indications of the analyses, contrary to the impressions of the writer, indicate that the maximum of this concentration is reached in the portion designated as dust, a portion whose individual particles have a diameter of less than 0.01 millimeter, or less than one twenty-five hundredths of an inch, and which constitutes 27.87 per cent. of this soil. The clay, which is still very much finer, contains, in this case, essentially the same percentage of potash, but constitutes only 8.31 per cent. of the soil. In this instance the dust and not the clay is the potash-carrying silt-constituent of the soil.

§ 40. The fine particles of the dust and clay are probably not wholly composed of fine residual parts of the minerals originally composing the soil mass, but are to a greater or less extent made up of newly formed particles of precipitates, or at least of newly formed minerals, which may adhere tenaciously to the fine residual grains or form independent little aggregates which, being disintegrated by the washing of the soil, are obtained in the form of clay.

#### ANALYSES OF PARTS OF FINE EARTH SHOW NO DEFINITE RATIOS.

§ 41. Little can be said in regard to the ratios existing between the various chemical constituents as shown in the preceding analyses. There is, for instance, no clear and definite relation between the potash and soda, iron oxide and alumina, alkalies and alkaline earths. The iron is, taken roughly, equal to one half of the alumina. This holds true for soil A, the parts of the soil separated by washing, and of the Larimer county loess. I am inclined to think that this is an accident, in spite of its occurring in each of these six instances. It is not the case in the Cheyenne loess, and extraction with hydrochloric acid shows it to be almost wholly soluble in this agent. Macroscopic observation, especially after



ignition, shows the sand grains to be coated to a greater or less extent with this substance, oxid of iron. It does not appear as red oxid of iron on the grains before ignition, but becomes evident after. This is well seen in the color of the mass before and after ignition. This suggests the existence of hydrates of iron or organic compounds, but the loss on ignition is so small and irregular, bearing in its quantity no relation to that of the iron, that the organic compounds, if any, are very small in amount. There seems to be, as we shall see later, but a small amount of iron present in the form of a silicate insoluble in hydrochloric acid, certainly not more than may be present in a perfectly fresh feldspar. This would still be the case if the quartz sand were all deducted or considered as carrying no iron whatever. The portion soluble in hydrochloric acid, on the other hand, is rich in iron. The total loss on ignition is not unusually large, and a portion of this is water retained at the temperature of  $110^{\circ}$  C, probably in the form of hydrated oxid of iron.

#### SOLVENT ACTION OF HYDROCHLORIC ACID ON THE SOIL.

§ 42. The portion of these soils dissolved or decomposed by hydrochloric acid, sp. gr. 1.115, upon digestion for five days, varied from 30 to 50 per cent. The amount dissolved certainly depends upon the character of the substances present in the samples, but in this respect our samples are very uniform, containing essentially the same mineralogical components. The variation in the amount dissolved depends upon other conditions, principally upon the fineness of the soil particles, and the particular degree of their decomposition. The former condition is the more important, as the latter one is largely dependent upon it. This is quite clearly seen upon a comparison of the mechanical analyses of these samples, taking the particles having a diameter greater than 0.05 millimeter as one group, and those of less diameter as another group. The amount dissolved under the conventional conditions, HCl, sp. gr. 1.115, and five days digestion on water bath, varies, but not closely, with the ratio of these two groups, into which every soil can be divided. In other words, it is the very fine particles of the soil which yield to the hydrochloric acid the elements of plant food found in the solution. This is unquestionably the case in the soil, as well as in the analysis. The decomposition of the minute particles of the minerals will take place more slowly in the soil solutions than in the hydrochloric acid, but the order in which they will be attacked is the same, the finest first.

#### RESULTS OF CHEMICAL ANALYSES NOT COMPETENT CRITERIA.

§ 43. The chemical analysis does not give us a good criterion by which to judge of the virtues of a soil. It may not follow the same course of decomposition that takes place in the soil, and it cer-

tainly extends too far, that is, we can not say how long it would take to effect the same amount of change by the soil agents, as is effected by an acid solution and heat during the five days digestion, or by strong acid in ten hours.

#### THE SAMPLES ANALYZED.

§ 44. The samples and the manner in which they were taken have already been described. Two sets of samples were taken, one on May 13, and another on October 20, 1897. These samples were taken from the same parts of the plot, in order to make them agree as nearly as we could. We hoped that the earlier samples would enable us to ascertain the composition of the soil, the later ones to determine, if possible, the effects of cultivating, irrigating, and cropping it. The crop grown was sugar beets. The work done on the crop, both in the field and laboratory, is recorded in Bulletin 46. The whole crop, both roots and tops, had been removed before we took the samples in October.

#### WATER RECEIVED.

§ 45. The rainfall was about 9 inches. The amount of irrigation water used in the two irrigations given was not measured, but was estimated by an experienced man to be about 8 inches, or approximately 17 inches in all. The drainage of this plot of ground is not good, and we now know that it receives water from the west as sub-irrigation. This we did not know at the beginning of our experiment, or rather we supposed that we were protected from this interference by a ditch and a drain. The water plane during this season was higher than during the succeeding season of 1898, but this, I think, was due in part to greater rainfall and more frequent irrigation. Two factors enter here which are wholly undetermined, the upward movement of the water-soluble salts in the soil, due to evaporation from the surface, and the salts removed by drainage. The former was made as low as our conditions would permit, by keeping the surface soil well stirred by frequent cultivations, and by the luxuriant growth made by the beet tops. I do not know how much either of these agencies accomplished during the season, nor do I know that any attempt has been made to determine the amount of evaporation from the surface of the soil at this place under any conditions. The amount of drainage from this plot was sufficient to lower the water table, after it had been raised by irrigating the plot, two feet in eleven days. In this case, the adjoining land had received no irrigation, and the rise in the water plane was purely local.

§ 46. The draining out of the water may have been due as much to a spreading of the water over a larger area, as to draining out. Under such conditions as the early summer season presented,



the fall of the water plane in this plot took place at the rate of one foot in thirty days. I would have assumed this to be the rate of drainage out of this area, had we not demonstrated, much against our will at the time, that there is a flow of water from the west into our plot, and the fall of one foot in thirty days is simply the excess of the drainage out of the area over that into it.

DEPARTMENT OF SOIL WITH WATER SHRINKAGE INCLUDED.

§ 47. I have stated twice that one characteristic of this soil is its retentiveness of moisture. I do not mean by this statement that it will refuse to give up a larger percentage of moisture than other soils, when exposed to drying out in the air or subjected to drought, but that excessive water is given up slowly, and also that when it dries it shrinks and becomes very hard, which is true of many soils in this State.

§ 48. I made two experiments to determine the rate at which this soil dries after being saturated with water, and also to determine the loss of volume due to shrinkage.

These samples deported themselves very differently. The sample of soil A, placed in a cylindrical box, showed moisture on the surface in seven minutes after the perforated bottom of the box was placed in water, but the soil had not become saturated at the expiration of four and one-quarter hours, and was permitted to stand in contact with the water over night. The sample of soil D, on the other hand, did not show moisture on the surface until forty-five minutes after it was placed in contact with the water, but was saturated in one and one-quarter hours. Soil A required for saturation 18.18 grams of water, and lost in eleven days 17.78 grams; D required 16.62 grams for saturation, and gave up 16.20 grams in eleven days. The shrinkage was the same in both cases, 28 per cent. of the original volume. The cylinders were filled and shaken down to make the soil compact. The loss for each twenty-four hours, up to the end of the seventh day, is given in the following table, together with that for pulverized feldspar, which was used for the sake of comparison. The feldspar had been pulverized so that its particles approached those of the soil as nearly as possible in size. The volumes were the same. It will be born in mind that the soil contains humus, clay, salts, etc., while the feldspar does not. The feldspar showed moisture in one minute after being placed in the water. One sample was saturated in ten and the other in twenty minutes. This is a very pronounced difference, the soils requiring 75 and upwards of 255 minutes for their saturation. The feldspars required for saturation 8.94 and 7.39 grams of water respectively, the soils, 18.18 and 16.60 grams.

TABLE IV.—RATES AT WHICH THE SOILS GAVE UP WATER.

|                                      | <i>Soil A.</i><br><i>Grams.</i> | <i>Soil D.</i><br><i>Grams.</i> | <i>Feldspar.</i><br><i>Grams.</i> | <i>Feldspar.</i><br><i>Grams.</i> |
|--------------------------------------|---------------------------------|---------------------------------|-----------------------------------|-----------------------------------|
| Water given up in first 24 hrs. .... | 3.58                            | 3.10                            | 2.06                              | 2.00                              |
| Water given up in second 24 hrs. ... | 2.45                            | 3.00                            | 2.52                              | 2.42                              |
| Water given up in third 24 hrs. .... | 2.47                            | 2.45                            | 1.99                              | 1.95                              |
| Water given up in fourth 24 hrs. ... | 2.33                            | 2.40                            | 1.85                              | 0.97                              |
| Water given up in fifth 24 hrs. .... | 2.40                            | 2.40                            | 0.06                              | 0.01                              |
| Water given up in sixth 24 hrs. .... | 2.10                            | 1.60                            | ....                              | ....                              |
| Water given up in seventh 24 hrs. .  | 1.20                            | 0.35                            | ....                              | ....                              |

The experiment with the soils was continued for four days longer, but the loss was comparatively slow. The feldspar showed no shrinkage. The temperatures at which these experiments were made were 15°–16° C. for the soil samples, and 16°–17° for the feldspars.

#### ANALYSES OF HYDROCHLORIC ACID SOLUTIONS OF THE SOILS.

§ 49. The description of these samples has been given in a preceding paragraph, and the method of analysis was a conventional one, digestion with hydrochloric acid, sp. gr. 1.115, on a water bath for five days.



TABLE V.—ANALYSES OF SOILS. GENERAL SAMPLES.

|                                      | A.<br>May 13,<br>1897. | B.<br>May 13,<br>1897. | C.<br>May 13,<br>1897. | D.<br>May 13,<br>1897. | E.<br>May 13,<br>1897. | F.<br>May 13,<br>1897. | A.<br>Oct. 20,<br>1897. | B.<br>Oct. 20,<br>1897. | C.<br>Oct. 20,<br>1897. | D.<br>Oct. 20,<br>1897. | E.<br>Oct. 20,<br>1897. | F.<br>Oct. 20,<br>1897. |
|--------------------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Insoluble .....                      | 53.470                 | 70.065                 | 58.951                 | 53.617                 | 62.572                 | 54.262                 | 50.228                  | 70.756                  | 51.047                  | 56.092                  | 61.871                  | 53.572                  |
| Silicic Acid, Soluble....            | 17.875                 | 11.379                 | 17.449                 | 18.662                 | 12.918                 | 12.126                 | 21.346                  | 11.587                  | 20.287                  | 17.926                  | 13.552                  | 10.671                  |
| Sulfuric Acid.....                   | 0.827                  | 0.488                  | 0.508                  | 0.921                  | 0.517                  | 0.529                  | 1.433                   | 0.486                   | 0.354                   | 0.927                   | 0.817                   | 0.237                   |
| Carbonic Acid.....                   | 1.208                  | Trace.                 | 0.652                  | 1.267                  | 2.251                  | 6.934                  | 0.419                   | Trace.                  | 0.949                   | 0.785                   | 1.991                   | 8.025                   |
| Chlorin .....                        | 0.014                  | 0.014                  | 0.031                  | 0.008                  | 0.033                  | 0.019                  | 0.034                   | 0.019                   | 0.004                   | 0.007                   | 0.007                   | 0.016                   |
| Phosphoric Acid.....                 | 0.112                  | 0.064                  | 0.081                  | 0.061                  | 0.070                  | 0.054                  | 0.086                   | 0.128                   | 0.115                   | 0.099                   | 0.138                   | 0.122                   |
| Potash .....                         | 1.495                  | 1.003                  | 1.443                  | 1.443                  | 0.876                  | 0.854                  | 1.528                   | 0.978                   | 1.457                   | 1.372                   | 0.936                   | 0.750                   |
| Soda .....                           | 0.624                  | 0.521                  | 0.589                  | 0.778                  | 0.610                  | 0.600                  | 0.722                   | 0.540                   | 0.618                   | 0.546                   | 0.535                   | 0.614                   |
| Lime .....                           | 2.479                  | 0.778                  | 1.029                  | 2.751                  | 3.698                  | 9.141                  | 1.944                   | 0.840                   | 1.602                   | 1.777                   | 3.129                   | 10.537                  |
| Magnesia .....                       | 1.649                  | 1.007                  | 1.429                  | 1.446                  | 1.081                  | 1.254                  | 1.697                   | 0.860                   | 1.737                   | 1.353                   | 1.198                   | 1.465                   |
| Ferric Oxid.....                     | 4.075                  | 3.575                  | 4.185                  | 4.225                  | 4.025                  | 3.630                  | 4.320                   | 3.385                   | 4.960                   | 4.170                   | 3.795                   | 3.600                   |
| Aluminic Oxid.....                   | 7.387                  | 4.484                  | 5.587                  | 6.733                  | 4.853                  | 5.190                  | 7.410                   | 4.264                   | 7.281                   | 6.492                   | 4.499                   | 3.756                   |
| Manganic Oxid (br)....               | 0.200                  | 0.120                  | 0.140                  | 0.190                  | 0.075                  | 0.065                  | 0.245                   | 0.130                   | 0.290                   | 0.095                   | 0.085                   | 0.190                   |
| Moisture at 100° C.....              | 3.296                  | 1.765                  | 2.004                  | 2.214                  | 2.020                  | 1.642                  | 2.990                   | 1.526                   | 2.853                   | 2.721                   | 2.109                   | 1.850                   |
| Ignition.....                        | 5.402                  | 3.976                  | 5.581                  | 4.417                  | 5.095                  | 4.103                  | 5.361                   | 4.017                   | 6.035                   | 5.470                   | 5.898                   | 5.223                   |
| Sum .....                            | 100.113                | 99.246                 | 99.659                 | 99.734                 | 100.694                | 100.403                | 99.763                  | 99.516                  | 99.489                  | 99.831                  | 100.460                 | 100.678                 |
| Oxygen Equivalent }<br>to Chlorin. } | 0.003                  | 0.003                  | 0.007                  | 0.002                  | 0.008                  | 0.004                  | 0.008                   | 0.004                   | 0.001                   | 0.001                   | 0.002                   | 0.004                   |
| Total .....                          | 100.110                | 99.243                 | 99.652                 | 99.732                 | 100.686                | 100.399                | 99.755                  | 99.512                  | 99.488                  | 99.830                  | 100.458                 | 100.674                 |
| Nitrogen .....                       | 0.0937                 | 0.0882                 | 0.0882                 | 0.0959                 | 0.1295                 | 0.1040                 | 0.0938                  | 0.1022                  | 0.1015                  | 0.1083                  | 0.1191                  | 0.0996                  |
| Humus.....                           | 0.8150                 | 0.9450                 | 0.7360                 | 0.6600                 | 0.8080                 | 0.5740                 | 0.7120                  | 0.9100                  | 0.7400                  | 0.8460                  | 1.0300                  | 0.5020                  |
| Phosphoric Acid }<br>in Humus. }     | 0.0384                 | 0.0205                 | 0.0296                 | 0.0288                 | 0.0486                 | 0.0384                 | 0.0333                  | 0.0345                  | 0.0396                  | 0.0294                  | 0.0537                  | 0.0334                  |

## CONSIDERATION OF ANALYTICAL RESULTS.

§ 50. There is no division of soil into surface and subsoil, except in the case of samples E and F, where E is the soil and F the subsoil. The mechanical and chemical analyses both show that there are marked differences.

The subsoil disappears entirely a few feet east of this point, and is entirely wanting at the point where sample D, the next on the east, was taken. The subsoil contains less decomposable silicates, corresponding to the soluble silicic acid, a considerable quantity of carbonate of lime, and a different mechanical composition.

The surface soils vary more than would be expected, and not in the manner that a knowledge of their physical appearance and deportment under cultivation would lead one to anticipate. Soil A becomes heavily incrustated with alkalies, the incrustation reaching a thickness, at times, of one half inch, while soil E does not at any time show an incrustation and would not be considered as containing any alkali, except for the marked amount of sulfuric acid appearing in the analysis. The carbonic acid in both samples appears to be in combination with calcium to the extent of about 50 per cent. in the case of A, and probably a still greater extent in the case of E. This is the case if the water-soluble portion of the sample represents the salts present in the soil, and no changes are induced by the long treatment with water necessary to remove all the soluble salts. We notice that the sulfuric acid in the samples of A and E, taken in October, is higher than in the samples taken in May. This may be due to a transference of the sulfates from the subsoil to the soil, but taking the two series of samples, we see that only two samples indicate any loss of sulfates, *i. e.*, samples C and F; and as already suggested, the loss in F may account, in part, for the gain in E.

§ 51. The carbonic acid does not give us any strong indication that the season's cropping and cultivation has eliminated much if any alkali from the soil, while the total soda present tends to show that the apparent diminution in the carbonic acid present is to be explained otherwise than by attributing it to any variation of the quantity of alkali. Samples E and D are from contiguous sections. E shows no alkali on the surface, while D shows an abundance of it. If, for the sake of simplicity, we calculate the sulfuric acid as corresponding to sodic sulfate in the soil, we observe that in May it ranges from 0.87 to 1.63 per cent., whereas in October it ranges from 0.63 to 2.54 per cent., one sample only, C, showing a decrease from 0.90 to 0.63 per cent. In the case of the subsoil F, we have a decrease from 0.94 to 0.42 per cent, but in the surface soil E, corresponding to it, we have an increase from 0.92 to 1.45 per cent.



§ 52. This soil E is in excellent condition and would ordinarily be considered free from alkali, but if we calculate the amount of sodic sulfate corresponding to the sulfuric acid in an acre of such soil taken to the depth of one foot, we find in round numbers 16 tons in May, and 25 tons in October. In the subsoil, sample F, we find in May 16 tons and in October 7 tons. It appears that 9 tons of this salt, or its equivalent, has been transferred from the subsoil to the soil by surface evaporation and capillarity, but no incrustation was produced. In the case of sample A, we find a little larger increase in the surface layers, but there is at times a heavy incrustation covering almost the whole of this section. This was not the case at the time the sample was taken. We have a marked change in the other direction in sample C, as we find that about four tons per acre of this salt has passed below the depth to which our sample was taken. It is possible that this salt was washed out or flooded off of this section of the plot at the rate of four tons per acre during the season. I would like to believe this, but I see no reason why I should. The ground here is about one foot higher than at B or D, and the irrigation water flowed towards these points, but there was no increase in the alkali at either B or D. In the case of F there is a patent explanation, in the case of C there is not. The sulfuric acid determinations were done in duplicate in both cases, and agreed within four one hundredths of one per cent. The crop as previously shown did not remove a large amount of sulfuric acid, and I have no explanation for the disappearance of the alkali from this section, unless it was simply carried into the soil by the irrigation and was not brought back by the capillary movement of the water within the reach of our sample. The differences in the percentages of the potash are so small, and the samples not being identical, there is not even the same small object in trying to draw any inferences from them, that there is discussing the effect of the season's work on the "alkali," basing it upon the total amount of sulfuric acid present in the different samples.

One could scarcely expect one season's study and work to produce a change of sufficient magnitude to show a decided difference in the results of such analyses, nor does the matter stand in a much more favorable relation at the end of three or four years. After three crops had been taken off of the plot, a sample from E showed the presence of 0.849 per cent. of potash, and before any crop had been taken off it showed 0.876 per cent. The plowing, cultivation, irrigation and cropping of three seasons gave us as their total effect this uncertain difference of 0.027 per cent. There were other samples taken, but these are the only two that coincide in the point at which they were taken. Others, however, show the same thing; sample B, for instance, at the beginning showed 1.003 per cent. of potash; after three crops had been taken, we obtained 0.999 per

cent. This shows nothing, because the samples were not taken from points near enough together. The samples of the third season were not taken for the purposes of such a comparison, and merely chance to serve even in this measure. The fact that the nitrogen content in the October samples was higher than in the May samples, has but little if any dependence upon the beet crop, but was possibly very dependent upon the cultivation and irrigation. It is, we may say, a distinct crop, which increases with favorable conditions of season and soil; and our analyses simply show that there was more in the soil on October 20 than on May 13, regardless of what had been removed by the crop or dissolved out by water.

§ 53. The effect upon the organic matter in the soil did not seem to be very decided, but at the end of three seasons there was a gain, not so large, however, as I expected, the tops of two crops of beets and a heavy coating of manure having been added to one half, on alternate sections, of the plot.

§ 54. The analyses, as we ought to expect, do not show us the changes which have really taken place. This plot, for instance, has improved most wonderfully in its quality, and the analyses do not and cannot measure these improvements. It is not a question of composition, but one of conditions.

#### SOME RESULTS DUE TO THE PRESENCE OF FELDSPAR.

§ 55. The consideration of the mineralogical constituents of the soil renders it evident that in our case we have to deal with the mineral feldspar, and indefinite decomposition products of this mineral, mixed with decaying organic matter. The agricultural analysis of the soil will yield results which will vary with the fineness of the feldspar particles the character of the decomposition products present, with slight variations in manipulation, and with other conditions which one cannot foresee. The minor variations, for instance in the percentages of potash found, as in case of sample A, 1.495 and 1.528, or in B, 1.003 and 0.978, may arise from such causes, and not depend in any way upon cropping or cultivation.

§ 56. As the solubility of feldspar in dilute acids is a well recognized property of this whole class of minerals, the results of the mineralogical study of these samples was somewhat disconcerting, not in regard to the value of such analyses in general, but of my analyses in particular. The abundance of this mineral present, the abundance of potash soluble in dilute acid, and the impossibility of washing out all the lime, soluble in dilute hydrochloric acid in any reasonable time, led me to experiment with orthoclase, powdered so fine that the whole mass would pass through a sieve with one millimeter mesh, because this is the conventional size of the particles of fine earth. Thirty-three per cent. of



this was less than one quarter of a millimeter in diameter. The mechanical analyses of the soils show that 60 per cent. of the soil particles are smaller than one fourth of a millimeter in diameter. This feldspar used had been washed out of the soil and was treated just as the soil was, and the results were as follows: Potash dissolved out of the feldspar by digesting with hydrochloric acid, sp. gr. 1.115, for five days, was 0.845 per cent.; soda, 0.816 per cent.; silicic acid set free, 4.31 per cent. This simple experiment is so decisive of the fact that five days digestion with dilute hydrochloric acid, sp. gr. 1.115, will extract potash from finely divided orthoclase in considerable quantities, that further questions arise as to whether plants can use the potash present in this form, or is our analysis of such a soil wholly misleading? The following questions are also suggested, viz: To what extent does water alone act on this mineral, for that water extracts potash from it is already an established fact, and how much does carbonic acid increase its solvent action?

#### ACTION OF WATER AND CARBONIC ACID ON FELDSPAR.

§ 57. The perfectly fresh, finely pulverized feldspar was suspended in water, 10 grams in 300 c. c., and allowed to stand five days with frequent shaking. One hundred c. c. of this solution was filtered off, evaporated to dryness, and the residue weighed. Another portion of feldspar was treated in the same manner, except that the water was saturated with carbonic oxid.

§ 58. A like quantity of water was placed beside these and carried through as a control.

§ 59. The water dissolved from the feldspar 0.0081 gram, after deducting the amount contained in the distilled water.

§ 60. The water charged with carbonic oxid dissolved 0.0723 gram. The residue obtained in this case gave a heavy precipitate for potash with platinic chlorid, as did the water solution of the feldspar. The residue from the distilled water did not react for potash.

#### EXPERIMENTS WITH OATS.

§ 61. This question was carried still further, and we endeavored to determine whether the feldspar could furnish potash to plants. For this purpose the perfectly fresh mineral was used, pulverized as already described in imitation of the soil, *i. e.*, the particles varied from one millimeter in diameter to an impalpable powder. This was mixed with pure quartz sand. Bone ash was used to supply lime and phosphoric acid. The sample used contained no potash. Nitrate of lime furnished the nitrogen. Chlorin was furnished by a minute quantity of calcic chloride. Distilled water was used throughout the experiment.

The plants grew healthily in this mixture until the floors of the

building were oiled and the room in which the plants were growing was shut up and became too warm; these two things together gave them a decided set back, and later a thrips, *Thrips striata*, according to Prof. Gillette, attacked the plants and did them much damage. Some of the plants, however, seeded. They were harvested, though in bad condition and very uneven in the degree of their development. The root system was well developed, the sand being filled with the roots. The weight of the tops as harvested was 198.5 grams; that of the roots as washed out was 40 grams. The tops and roots were incenerated together and yielded 5.795 per cent. of soluble and 9.803 per cent. of insoluble ash, a total of 15.598 per cent.

§ 62. Examination of the feldspar used showed the presence of 11.993 per cent. of potash, and 2.988 per cent. of soda. Phosphoric and sulfuric acids were present in very small quantities, the former equalled 0.041 per cent. and the latter 0.003 per cent. of the feldspar.

§ 63. The nitrogen in the oat hay, roots included, was 3.2543 per cent.

The ash gave the following analysis:

TABLE VI.—ANALYSIS OF OAT ASH GROWN WITH FELDSPAR.

|                                   | <i>Per Cent</i> |
|-----------------------------------|-----------------|
| Carbon .....                      | 0.172           |
| Sand.....                         | 8.135           |
| Silicic Acid.....                 | 15.737          |
| Sulfuric Acid.....                | 4.411           |
| Phosphoric Acid.....              | 3.982           |
| Carbonic Acid.....                | 15.356          |
| Chlorin.....                      | 2.732           |
| Potassic Oxid.....                | 15.959          |
| Sodic Oxid.....                   | 4.622           |
| Calcic Oxid.....                  | 21.709          |
| Magnesian Oxid.....               | 3.906           |
| Ferric Oxid.....                  | 0.696           |
| Aluminic Oxid.....                | 0.314           |
| Manganic Oxid.....                | 0.163           |
| Ignition .....                    | 2.611           |
| Sum.....                          | 100.505         |
| Oxygen Equivalent to Chlorin..... | 0.615           |
| Total .....                       | 99 890          |

RESULTS SHOWN BY EXPERIMENT WITH FELDSPAR.

§ 64. This ash is very anomalous in its composition as well as in the quantity present in the plants. The plants were not evenly mature at the time of gathering and were in bad condition. The question we endeavored to investigate, however, is perfectly answered by the results, *i. e.*, the oat plant can use the finely divided feldspar as a source from which to obtain potash; for in this experiment, made under very adverse conditions, we find that the oat plants



took from the feldspar 1.4417 grams of potash. The potash added in the seed has been deducted. The silicic acid appropriated by the plant indicates the decomposition of the silicate. The partially decomposed, finely comminuted feldspar is actually a part of the soil. Its deportment toward water, especially when charged with carbonic oxid, is also strongly suggestive of this conclusion.

§ 65. This fact is of very general importance, as it applies to so large a portion of our soils; it also facilitates the interpretation of our analytical data, and enhances their value a little. The mass analyses show that our soils contain from 2.24 to 2.50 per cent. of potash—the latter seems to be the rule, about 2.50 per cent. The agricultural analysis of samples from all parts of the State show a range from 0.10 to 1.50 per cent. In fifty-eight analyses of samples from different counties of the State, only five fall so low as 0.15, and very few of the rest so low as 0.25 per cent. It is evident that, so far as the results of analyses are reliable, the soil with which we have been experimenting is richer in this constituent than the average soil. This is, I believe, true of all of alkali land.

#### ANALYSIS OF THE ACID SOLUBLE AND INSOLUBLE PORTION OF SOIL A.

§ 66. The mineralogical composition of our soil, *i. e.*, quartz and feldspar, and the decomposition products of the latter, together with the results of our experiments with feldspar, suggest the combination of the mass analysis and agricultural analysis to give us some idea of the relation of the agricultural analysis to the actual composition of the soil. We, therefore, in order to exhibit as fully as we can the chemical composition of this soil, give the agricultural analysis of soil A, together with the analysis of the residue designated as insoluble in the agricultural analysis.

TABLE VII.—ANALYSES OF THE ACID SOLUBLE AND INSOLUBLE PORTION OF SOIL A.

|                         | <i>Soluble in HCl., sp. gr.<br/>1.115, 5 days digestion.<br/>Per cent.</i> | <i>Insoluble in HCl., sp. gr.<br/>1.115, 5 days digestion.<br/>Per cent.</i> |
|-------------------------|----------------------------------------------------------------------------|------------------------------------------------------------------------------|
| Silicic Acid.....       | 17.875                                                                     | 46.870                                                                       |
| Sulfuric Acid.....      | 0.827                                                                      | None                                                                         |
| Carbonic Acid.....      | 1.208                                                                      | .....                                                                        |
| Chlorin .....           | 0.014                                                                      | .....                                                                        |
| Phosphoric Acid.....    | 0.112                                                                      | None                                                                         |
| Potash .....            | 1.495                                                                      | 0.800                                                                        |
| Soda .....              | 0.624                                                                      | 0.560                                                                        |
| Lime.....               | 2.479                                                                      | 0.310                                                                        |
| Magnesia.....           | 1.649                                                                      | 0.170                                                                        |
| Ferric Oxid.....        | 4.075                                                                      | 0.400                                                                        |
| Aluminic Oxid .....     | 7.387                                                                      | 4.330                                                                        |
| Manganic Oxid.....      | 0.200                                                                      | Trace                                                                        |
| Moisture at 100° C..... | 3.296                                                                      | .....                                                                        |
| Ignition .....          | 5.402                                                                      | .....                                                                        |
|                         | <hr/> 46.640                                                               | <hr/> 53.440                                                                 |
| Total.....              |                                                                            | 100.080                                                                      |

## DISCUSSION OF ANALYSIS.

§ 67. This analysis shows that 65 per cent. of the potash, 63 per cent. of the alumina, 90 per cent. of the oxid of iron, 27.6 per cent. of the silicic acid, a very high percentage of the lime and magnesia, and the whole of the sulfuric and phosphoric acids, were removed or, as in the case of the silicic acid, rendered soluble in sodic carbonate. If the silicic acid rendered soluble by this treatment be taken as the measure, then the action of the hydrochloric acid on the soil was between six and seven times as great as it was on pure feldspar, and probably not more than one sixth of the silicic acid could come from the decomposition of this mineral. The potash dissolved out of the soil is about 75 per cent. greater than was taken into solution from the pure, fresh mineral. The relative amount of soda dissolved out of the feldspar was high compared with the amount of potash dissolved, but low when compared with the percentage of soda dissolved out of the soil. A glance at the analysis shows that, taken roughly, 50 per cent. of the soda in the soil was dissolved out, but only about 25 per cent. of it went into solution in the case of the feldspar. The relatively large amount of soda dissolved out of the feldspar by digestion with the dilute hydrochloric acid, is probably due to the fact that the feldspar used was not wholly composed of the potash feldspar, orthoclase, but may have contained an admixture of oligoclase, another feldspar, rich in soda and more readily attacked by acids. When we take up the portion of the soil soluble in water we shall see that some, as much perhaps as one third, of the soda is present in a form readily soluble in this menstruum, and in this case belongs to the "alkalis" present.

## THE WATER-SOLUBLE IN THE SOIL.

§ 68. When these soils are treated with fresh portions of water, so long as they yield either chlorin or sulfuric acid to the water and the amount taken into solution is determined, we find it ranging from 0.389 per cent. to 2.550 per cent. Soil A yielded the highest amount to water, 2.55 per cent., taking the sample to a depth of ten inches, and as high as 3.93 per cent. taking the first two inches of the soil.

§ 69. In stating the analyses of the portions of different samples soluble in water, I have combined the acids and bases and give the salts alongside of the direct analytical results. The order followed in combining them will be apparent to anyone upon an inspection of an analysis. I have adopted this order and have been as uniform as possible throughout. This order is convenient and probably represents the salts present in the soil as nearly as any other which might have been adopted, but it is certainly not always correct.



§ 70. The water-soluble has been determined in one set of general samples, but has been analyzed in only one case, that of sample B, taken in 1897. The analysis is not wholly satisfactory, showing too large an excess of sodic oxid, even after using all of the silicic acid present. A large quantity of organic matter in an analysis is sometimes accompanied by an excess of soda. This analysis was made on a smaller amount of material than the analyst was accustomed to, and other conditions did not contribute either to his comfort or to the accuracy of his work. The water-soluble amounted in this instance to 0.878 per cent. of the soil.

TABLE VIII.—ANALYSIS OF THE WATER-SOLUBLE IN SAMPLE B, 1897.

|                               | <i>Per cent.</i> | <i>Combined.</i>             | <i>Per cent.</i> |
|-------------------------------|------------------|------------------------------|------------------|
| Silicic Acid .....            | 1.516            | Calcic Sulfate.....          | 36.633           |
| Sulfuric Acid.....            | 50.451           | Magnesian Sulfate.....       | 22.824           |
| Carbonic Acid.....            | 0.140            | Potassic Sulfate.....        | 4.659            |
| Chlorin .....                 | 1.529            | Sodic Sulfate .....          | 20.513           |
| Sodic Oxid.....               | 14.423           | Sodic Chlorid.....           | 2.523            |
| Potassic Oxid.....            | 2.517            | Sodic Carbonate.....         | 0.337            |
| Calcic Oxid.....              | 15.091           | Sodic Silicate.....          | 3.078            |
| Magnesian Oxid .....          | 7.608            | Aluminic and Ferric Oxids... | 0.152            |
| Aluminic and Ferric Oxids...  | 0.152            | Manganic Oxid .....          | not det.         |
| Manganic Oxid (br) .....      | not det.         | Ignition .....               | 6.885            |
| Ignition .....                | 6.885            |                              |                  |
| Sum.....                      | 100.312          | Sum.....                     | 97.604           |
| Oxygen Equivalent to Chlorin: | 0.344            | Excess of Soda.....          | 2.400            |
| Total .....                   | 99.968           | Total .....                  | 100.004          |

§ 71. Analysis shows that the whole of the sulfuric acid in these soils is soluble in water and in hydrochloric acid. The soil analysis of B, sample taken May 13, was made on the same sample that was extracted with water and the analysis of which extract is given above. The difference when the sulfuric acid is calculated into percentage of the soil is far within the limit of the analytical errors, being only 0.045 per cent. In regard to the order in which the acids and bases have been combined, it appears that there is but little choice. The water-soluble consists essentially of sulfates. The above residue was obtained by washing the soil so long as the water with which it was digested in the cold for twenty-four hours showed any trace of sulfuric acid. The water used in the particular case given, sample B, was not measured, but it was in all of the cases to be given and ranged from 18 to 45.5 litres per 1,000 grams of the soil.

THE WATER-SOLUBLE PORTION OF THE SOIL DIFFERENT FROM THE INCRUSTATION.

§ 72. It may be well to anticipate a later discussion to the extent of stating that the water-soluble in the soil is not the same, as the "alkali" that effloresces from the soil. The salts are of the same

kind, sulfates, but while the predominant soluble salt in the soil is calcic sulfate, that in the alkali which effloresces from this ground is sodic sulfate, with magnesian sulfate second in quantity, while the calcic sulfates is but little greater than the sodic chlorid.

§ 73. The analysis is not unsupported in showing a large amount of calcic sulfate to be present. I caused several boxes of the soil to be gathered and planted with beet seed. These boxes were covered with glass and left standing for some days. When they were examined again there was an abundant crop of fine acicular crystals of gypsum uniformly distributed over the surface. Inspection of the soil as it was turned up by the plow also showed this substance to be present. Its abundance suggested the possibility of this soil having sometime received a heavy dressing of gypsum, in the hope of correcting the evil of the alkali, but I could not learn that such had been the case, and the presence of the gypsum in its present quantity seems to be due to accumulation of this salt from the evaporation of the ground water.

#### WATER-SOLUBLE PORTION OF THE SOIL DIFFERENT FROM SALTS IN GROUND WATER.

§ 74. The salts held in solution by the ground water agree more nearly with the water soluble in the soil than those which effloresce and are considered as alkali, but even the ground waters are not solutions of the water soluble portion in the soil. They differ in two essentials, in the amount of silicic acid and also in that of potash, which they contain. The water-soluble portion of the soils being richer in these constituents, sometimes containing ten times as much of one or the other of these. The water-soluble in the soil, on the other hand, is not at all uniform in its relative content of sodic sulfate, and is oftener poor in this salt than even mediumly rich. In only two cases out of the eight following analyses does it constitute any considerable fraction of the water-soluble salts, and in these cases its presence in such large quantity, 17.7 and 27.2 per cent. of the soluble salts, is probably due to its concentration at the surface and its subsequent washing back into the soil, as the samples represented the first two inches of the soil from sections where efflorescences are always formed under favorable conditions. The fact that the water-soluble salts are richer in potash than the soil water is explicable by the facts which have been demonstrated, by the action of water on the feldspar and the property of certain compounds in the soil of exchanging lime for potash brought into contact with them through the agency of solutions, the ground water being in this manner deprived of its potash, receiving lime in exchange. The analyses of the parts of the soil classified according to the size of their grains showed an increasing percentage of potash as the grains of the respective parts became



finer, until it reached its maximum in the dust and clay. The continued treatment with pure water, used in small portions at a time, yet relatively large compared with that acting upon the same amount of soil in the field, may act more energetically upon the feldspar than the soil waters do, but in considering this the presence of carbonic acid in the soil is not to be neglected, as it strongly tends to increase the solvent action of water upon this mineral.

§ 75. The analyses of the water-soluble portion of these soils show, as a rule, very much more silicic acid than is present in the residues from the ground waters. This fact, together with the higher percentage of potash which the water-soluble portions uniformly contain, suggest that the reaction itself is either primarily different or that there is a subsequent reaction between the ground water solution and the soil. The known ability of soils to remove potash from solutions seems to make it probable that such secondary reaction takes place. The more exact nature of this reaction is not known. I believe, however, that such a reaction would account very largely, if not wholly, for the accumulation of the potash in the very fine portions of the soil, among which these newly formed and highly reactive compounds are included.

#### THE WATER-SOLUBLE PORTION OF THE SOIL.

§ 76. The following tables exhibit the composition of the water-soluble portions of the first and second two inches of the soil. They give us an idea of the differences which exist in the salts of the different layers of the soil, but no correct idea of the distribution of the alkali, for the samples were taken on different dates.

That which has already been said in regard to the order in which the acids and bases, oxids, have been combined probably needs to be emphasized. The order adopted seems to be the most convenient one for the majority of cases, and approximates the facts in these cases, but is not always correct. Phosphoric acid, when found in these residues, has been combined with magnesia. While this may be correct, it is more probable that it was in combination with lime. Its quantity, however, is so small that no great violence is done to our knowledge or to the facts.

TABLE IX.—WATER-SOLUBLE, SOIL A, FIRST TWO INCHES.

|                               | <i>Per cent.</i> |                               | <i>Combined.</i> | <i>Per cent.</i> |
|-------------------------------|------------------|-------------------------------|------------------|------------------|
| Silicic Acid .....            | 0.574            | Calcic Sulfate .....          | 39.289           |                  |
| Sulfuric Acid .....           | 49.411           | Magnesian Sulfate .....       | 22.924           |                  |
| Phosphoric Acid .....         | None             | Potassic Sulfate .....        | 2.263            |                  |
| Carbonic Acid .....           | 0.721            | Sodic Sulfate .....           | 17.728           |                  |
| Chlorin .....                 | 5.557            | Sodic Chlorid .....           | 9.167            |                  |
| Potassic Oxid .....           | 1.223            | Sodic Carbonate .....         | 1.737            |                  |
| Sodic Oxid .....              | 14.301           | Sodic Silicate .....          | 1.165            |                  |
| Calcic Oxid .....             | 16.189           | Aluminic and Ferric Oxids ... | Trace            |                  |
| Magnesian Oxid .....          | 7.635            | Manganic Oxid .....           | 0.297            |                  |
| Aluminic and Ferric Oxids ... | Trace            | Ignition .....                | 5.058            |                  |
| Manganic Oxid .....           | 0.297            |                               |                  |                  |
| Ignition .....                | 5.058            |                               |                  |                  |
|                               |                  | Sum .....                     | 99.628           |                  |
| Sum .....                     | 100.966          | Excess of Sodic Oxid .....    | 0.081            |                  |
| Oxygen Equivalent to Chlorin. | 1.252            |                               |                  |                  |
|                               |                  | Total .....                   | 99.709           |                  |
| Total .....                   | 99.714           |                               |                  |                  |

The percentage of water-soluble equalled 3.93.

TABLE X.—WATER-SOLUBLE, SOIL A, SECOND TWO INCHES.

|                               | <i>Per cent.</i> |                               | <i>Combined.</i> | <i>Per cent.</i> |
|-------------------------------|------------------|-------------------------------|------------------|------------------|
| Silicic Acid .....            | 1.999            | Calcic Sulfate .....          | 64.594           |                  |
| Sulfuric Acid .....           | 51.740           | Magnesian Sulfate .....       | 20.642           |                  |
| Phosphoric Acid .....         | 0.129            | Magnesian Phosphate .....     | 0.229            |                  |
| Carbonic Acid .....           | 3.092            | Magnesian Carbonate .....     | 1.285            |                  |
| Chlorin ..                    | 0.939            | Potassic Carbonate .....      | 2.185            |                  |
| Potassic Oxid .....           | 1.490            | Sodic Carbonate .....         | 4.157            |                  |
| Sodic Oxid .....              | 4.429            | Sodic Chlorid ...             | 1.549            |                  |
| Calcic Oxid .....             | 26.617           | Sodic Silicate .....          | 2.312            |                  |
| Magnesian Oxid .....          | 7.591            | Aluminic and Ferric Oxids ... | 0.161            |                  |
| Aluminic and Ferric Oxids ... | 0.161            | Manganic Oxid .....           | 0.209            |                  |
| Manganic Oxid .....           | 0.209            | Ignition .....                | 2.173            |                  |
| Ignition .....                | 2.173            |                               |                  |                  |
|                               |                  | Sum .....                     | 99.496           |                  |
| Sum .....                     | 100.569          | Excess of Silicic Acid .....  | 0.861            |                  |
| Oxygen Equivalent to Chlorin. | 0.212            |                               |                  |                  |
|                               |                  | Total .....                   | 100.357          |                  |
| Total .....                   | 100.357          |                               |                  |                  |

The percentage of water-soluble equalled 2.55.

TABLE XI.—WATER-SOLUBLE, SOIL B, FIRST TWO INCHES.

|                               | <i>Per cent.</i> |                               | <i>Combined.</i> | <i>Per cent.</i> |
|-------------------------------|------------------|-------------------------------|------------------|------------------|
| Silicic Acid .....            | 1.348            | Calcic Sulfate .....          | 33.733           |                  |
| Sulfuric Acid .....           | 47.649           | Magnesian Sulfate .....       | 16.108           |                  |
| Phosphoric Acid .....         | None             | Potassic Sulfate .....        | 3.789            |                  |
| Carbonic Acid .....           | 1.311            | Sodic Sulfate .....           | 27.229           |                  |
| Chlorin .....                 | 4.008            | Sodic Chlorid .....           | 6.612            |                  |
| Potassic Oxid .....           | 2.048            | Sodic Carbonate .....         | 3.158            |                  |
| Sodic Oxid .....              | 18.632           | Sodic Silicate .....          | 2.714            |                  |
| Calcic Oxid .....             | 13.900           | Aluminic and Ferric Oxids ... | 0.113            |                  |
| Magnesian Oxid .....          | 5.365            | Manganic Oxid .....           | 0.266            |                  |
| Aluminic and Ferric Oxids ... | 0.113            | Ignition .....                | 6.281            |                  |
| Manganic Oxid .....           | 0.266            |                               |                  |                  |
| Ignition .....                | 6.281            |                               |                  |                  |
|                               |                  | Sum .....                     | 100.003          |                  |
| Sum .....                     | 100.921          | Excess of Silicic Acid .....  | 0.012            |                  |
| Oxygen Equivalent to Chlorin. | 0.903            |                               |                  |                  |
|                               |                  | Total .....                   | 100.015          |                  |
| Total .....                   | 100.018          |                               |                  |                  |

The percentage of the water-soluble equalled 0.75.



TABLE XII.—WATER-SOLUBLE, SOIL B, SECOND TWO INCHES.

|                               | <i>Per cent.</i> |                                 | <i>Combined.</i> | <i>Per cent.</i> |
|-------------------------------|------------------|---------------------------------|------------------|------------------|
| Silicic Acid .....            | 6.768            | Calcic Sulfate .....            | 46.510           |                  |
| Sulfuric Acid .....           | 40.378           | Magnesian Sulfate .....         | 16.939           |                  |
| Phosphoric Acid .....         | 0.407            | Magnesian Phosphate .....       | 0.751            |                  |
| Carbonic Acid .....           | 4.738            | Magnesian Chlorid .....         | 2.296            |                  |
| Chlorin .....                 | 2.821            | Potassic Sulfate .....          | 3.778            |                  |
| Potassic Oxid .....           | 2.042            | Sodic Chlorid .....             | 1.825            |                  |
| Sodic Oxid .....              | 9.826            | Sodic Carbonate .....           | 11.414           |                  |
| Calcic Oxid .....             | 19.165           | Sodic Silicate .....            | 4.295            |                  |
| Magnesian Oxid .....          | 6.954            | Aluminic and Ferric Oxids ..... | 0.390            |                  |
| Aluminic and Ferric Oxids ..  | 0.390            | Manganic Oxid .....             | 0.760            |                  |
| Manganic Oxid .....           | 0.760            | Ignition .....                  | [6.387]          |                  |
| Ignition .....                | [6.387]          |                                 |                  |                  |
| Sum .....                     | 100.636          | Sum .....                       | 95.345           |                  |
| Oxygen Equivalent to Chlorin. | 0.636            | Excess of Silicic Acid .....    | 4.654            |                  |
| Total .....                   | 100.000          | Total .....                     | 99.999           |                  |

The percentage of water-soluble equalled 0.389.

TABLE XIII.—WATER-SOLUBLE, SOIL C, FIRST TWO INCHES.

|                                 | <i>Per cent.</i> |                                 | <i>Combined.</i> | <i>Per cent.</i> |
|---------------------------------|------------------|---------------------------------|------------------|------------------|
| Silicic Acid .....              | 1.084            | Calcic Sulfate .....            | 43.260           |                  |
| Sulfuric Acid .....             | 48.826           | Magnesian Sulfate .....         | 24.260           |                  |
| Phosphoric Acid .....           | None             | Potassic Sulfate .....          | 2.475            |                  |
| Carbonic Acid .....             | 0.385            | Sodic Sulfate .....             | 10.789           |                  |
| Chlorin .....                   | 4.321            | Sodic Chlorid .....             | 7.128            |                  |
| Potassic Oxid .....             | 1.338            | Sodic Carbonate .....           | 0.928            |                  |
| Sodic Oxid .....                | 10.190           | Sodic Silicate .....            | 2.202            |                  |
| Calcic Oxid .....               | 17.826           | Aluminic and Ferric Oxids ..... | —                |                  |
| Magnesian Oxid .....            | 8.050            | Manganic Oxid .....             | 0.342            |                  |
| Aluminic and Ferric Oxids ..... | —                | Ignition .....                  | 8.281            |                  |
| Manganic Oxid .....             | 0.342            |                                 |                  |                  |
| Ignition .....                  | 8.281            | Sum .....                       | 99.665           |                  |
| Sum .....                       | 100.673          | Excess of Sodic Oxid .....      | 0.031            |                  |
| Oxygen Equivalent to Chlorin.   | 0.973            | Total .....                     | 99.696           |                  |
| Total .....                     | 99.700           |                                 |                  |                  |

The percentage of water-soluble equalled 2.0544.

TABLE XIV.—WATER-SOLUBLE, SOIL C, SECOND TWO INCHES.

|                                 | <i>Per cent.</i> |                                 | <i>Combined.</i> | <i>Per cent.</i> |
|---------------------------------|------------------|---------------------------------|------------------|------------------|
| Silicic Acid .....              | 9.095            | Calcic Sulfate .....            | 50.917           |                  |
| Sulfuric Acid .....             | 34.832           | Magnesian Sulfate .....         | 3.197            |                  |
| Phosphoric Acid .....           | 0.522            | Potassic Sulfate .....          | 6.016            |                  |
| Carbonic Acid .....             | 5.558            | Magnesian Phosphate .....       | 0.963            |                  |
| Chlorin .....                   | 2.663            | Magnesian Chlorid .....         | 3.565            |                  |
| Potassic Oxid .....             | 3.252            | Magnesian Carbonate .....       | 8.646            |                  |
| Sodic Oxid .....                | 8.778            | Sodic Carbonate .....           | 2.490            |                  |
| Calcic Oxid .....               | 20.981           | Sodic Silicate .....            | 14.418           |                  |
| Magnesian Oxid .....            | 7.131            | Aluminic and Ferric Oxids ..... | 0.898            |                  |
| Aluminic and Ferric Oxids ..... | 0.878            | Manganic Oxid .....             | 0.245            |                  |
| Manganic Oxid .....             | 0.245            | Ignition .....                  | 6.996            |                  |
| Ignition .....                  | 6.996            |                                 |                  |                  |
| Sum .....                       | 100.951          | Sum .....                       | 98.351           |                  |
| Oxygen Equivalent to Chlorin.   | 0.600            | Excess of Silicic Acid .....    | 1.998            |                  |
| Total .....                     | 100.351          | Total .....                     | 100.349          |                  |

The percentage of water-soluble equalled 0.813.

TABLE XV.—WATER-SOLUBLE, SOIL D, FIRST TWO INCHES.

|                               | <i>Per cent.</i> |                               | <i>Combined.</i> | <i>Per cent.</i> |
|-------------------------------|------------------|-------------------------------|------------------|------------------|
| Silicic Acid .....            | 2.261            | Calcic Sulfate.....           | 53.593           |                  |
| Sulfuric Acid .....           | 48.354           | Magnesian Sulfate.....        | 16.473           |                  |
| Phosphoric Acid .....         |                  | Potassic Sulfate.....         | 7.015            |                  |
| Carbonic Acid .....           | 0.768            | Sodic Sulfate .....           | 4.682            |                  |
| Chlorin .....                 | 2.670            | Sodic Chlorid.....            | 4.405            |                  |
| Potassic Oxid.....            | 3.792            | Sodic Carbonate .....         | 1.841            |                  |
| Sodic Oxid.....               | 5.604            | Sodic Silicate.....           | 0.282            |                  |
| Calcic Oxid.....              | 22.084           | Aluminic and Ferric Oxids ... | 0.011            |                  |
| Magnesian Oxid.....           | 5.486            | Manganic Oxid .....           | 0.662            |                  |
| Aluminic and Ferric Oxids ... | 0.011            | Ignition .....                | 8.789            |                  |
| Manganic Oxid .....           | 0.662            |                               |                  |                  |
| Ignition .....                | 8.789            |                               |                  |                  |
|                               |                  | Sum.....                      | 97.753           |                  |
| Sum.....                      | 100.477          | Excess of Silicic Acid .....  | 2.122            |                  |
| Oxygen Equivalent to Chlorin. | 0.602            |                               |                  |                  |
|                               |                  | Total .....                   | 99.875           |                  |
| Total .....                   | 99.875           |                               |                  |                  |

The percentage of water-soluble equalled 0.800.

TABLE XVI.—WATER-SOLUBLE, SOIL D, SECOND TWO INCHES.

|                               | <i>Per cent.</i> |                               | <i>Combined.</i> | <i>Per cent.</i> |
|-------------------------------|------------------|-------------------------------|------------------|------------------|
| Silicic Acid .....            | 3.354            | Calcic Sulfate.....           | 67.116           |                  |
| Sulfuric Acid .....           | 44.392           | Magnesian Sulfate.....        | 7.397            |                  |
| Phosphoric Acid .....         | Trace            | Magnesian Carbonate.....      | 7.202            |                  |
| Carbonic Acid .....           | 5.738            | Potassic Carbonate.....       | 1.922            |                  |
| Chlorin .....                 | 0.632            | Sodic Chlorid.....            | 1.042            |                  |
| Potassic Oxid.....            | 1.310            | Sodic Carbonate .....         | 3.265            |                  |
| Sodic Oxid.....               | 5.594            | Sodic Silicate.....           | 6.164            |                  |
| Calcic Oxid.....              | 27.656           | Aluminic and Ferric Oxids ... | 0.443            |                  |
| Magnesian Oxid.....           | 5.895            | Manganic Oxid .....           | 0.227            |                  |
| Aluminic and Ferric Oxids ... | 0.443            | Ignition .....                | 4.919            |                  |
| Manganic Oxid .....           | 0.227            |                               |                  |                  |
| Ignition .....                | 4.919            |                               |                  |                  |
|                               |                  | Sum.....                      | 99.697           |                  |
| Sum.....                      | 100.160          | Excess of Silicic Acid .....  | 0.321            |                  |
| Oxygen Equivalent to Chlorin. | 0.142            |                               |                  |                  |
|                               |                  | Total .....                   | 100.018          |                  |
| Total .....                   | 100.018          |                               |                  |                  |

The percentage of water-soluble equalled 0.864.

§ 77. The quantity of water used in extracting the soils ranged from 18 to 45.5 litres, and the time of extracting from 14 to 68 days. It was thought that the long time and large quantities of water used might have made some differences in the results which a quick extraction would make evident, but two experiments made on quantities of 10 and 150 grams each failed to show anything of sufficient interest to lead us to prosecute the work. The silicic acid, sulfuric acid, lime and magnesia extracted from 10 grams in from 30 to 45 minutes differed but a few hundredths of a per cent., when calculated on the soil used, from the figures obtained in the more carefully prepared extract. In the experiment with 150 grams the alkalies and magnesia with the silicic acid went into solution more readily than the last portions of lime and sulfuric acid. This is entirely in accordance with the properties of these



sulfates, but tends to show that the silicic acid is present as easily soluble silicates, probably as an alkaline silicate.

THE DISTRIBUTION OF THE SALTS IN THE FIRST AND SECOND TWO INCHES OF THE SOIL.

§ 78. I regret exceedingly that these sets of samples were not taken on the same date, but the record shows them to have been taken nearly a year apart. The set representing the first two inches having been taken in June, 1899, and that representing the second two inches in May, 1900. The two series are not comparable, except in a very general way, but the members of the series are perfectly so among themselves. The larger features of their differences are probably thoroughly representative of the facts, and show that the first two inches of the soil contains a somewhat higher percentage of soluble salts than the second two inches; that the sodic and magnesian sulfates constitute a materially higher percentage of these salts than they do in the second two inches; that the first two yielded less silicic acid than the second two inches; that the potassic oxid soluble in water is very irregular, but is present in both series in significant quantities; that there is no soluble phosphoric acid in the series representing the first two inches, and is present throughout that representing the second two inches. I was at first inclined to think that this was an error, but it is not. The plots from which these samples were taken had been cultivated, but had not received any manure.

§ 79. The uniformity of the presence of phosphoric acid as well as the significant quantity in which it is present is a matter of some surprise. Phosphoric acid is sometimes present in drainage waters in appreciable quantities, but usually only in traces. I have repeatedly tested the residues obtained by evaporating the ground waters of this plot for phosphoric acid, but I have not been able to prove the presence of a trace of it.

In regard to the silicic acid, a trifling amount of it might have been derived from the glass by solution, aided by the repeated shaking of the mass in the bottles, but the solutions made quickly, using freshly distilled water, gave the same results.

THE ALKALI.

§ 80. The efflorescence which forms on the surface of the soil is popularly called alkali, and is of common occurrence in many places in all parts of the State. It is not my intention to go into this subject at present, except as it pertains to this particular soil.

§ 81. There are small areas almost everywhere, especially in irrigated sections, which at times are white with a crop of these salts. They are not sightly from the agriculturists' standpoint, but are much less injurious in themselves than the conditions which admit of their formation. We have seen that among the salts

present in the soil are sodic, magnesian and calcic sulfates, and sodic chlorid. This is not the order, according to the respective quantities in which they occur in the soil, but in the incrustation formed on the top of the soil. There is an order, seemingly, in which the salts come to the surface or are brought there by capillary action, the sodic and magnesian sulfates forming some 80 per cent. of the total salts brought to the surface and deposited from the solutions in this soil. The character of these deposits, these alkalies, will vary in different localities. This variation undoubtedly depends upon the nature of the solutions in the soil, *i. e.*, the salts present in the ground water, rather than upon the nature of the water extract which we may be able to make of the soil. The salts present in the ground waters are intermediate in the order of their relative quantities between the water-soluble in the soil and the alkali incrustation, but are of the same kind. The analyses already given of the water-soluble salts, and those given in the following tables, represent the extremes for our soil.

TABLE XVII.—ANALYSIS OF ALKALI FROM SOIL A, JUNE 23, 1897.

|                               | <i>Per cent.</i> |                              | <i>Combined.</i> | <i>Per cent.</i> |
|-------------------------------|------------------|------------------------------|------------------|------------------|
| Silicic Acid.....             | 0.282            | Calcic Sulfate.....          |                  | 7.518            |
| Sulfuric Acid.....            | 53.637           | Magnesian Sulfate.....       |                  | 27.408           |
| Carbonic Acid.....            | 0.513            | Potassic Sulfate.....        |                  | 0.963            |
| Chlorin.....                  | 2.103            | Sodic Sulfate.....           |                  | 53.682           |
| Potassic Oxid.....            | 0.520            | Sodic Chlorid.....           |                  | 3.470            |
| Sodic Oxid.....               | 28.259           | Sodic Carbonate.....         |                  | 1.237            |
| Calcic Oxid.....              | 3.097            | Sodic Silicate.....          |                  | 0.572            |
| Magnesian Oxid.....           | 9.136            | Aluminic and Ferric Oxids... |                  | 0.090            |
| Aluminic and Ferric Oxids...  | 0.090            | Manganic Oxid.....           |                  | 0.117            |
| Manganic Oxid.....            | 0.117            | Ignition.....                |                  | 3.112            |
| Ignition.....                 | 3.112            |                              |                  |                  |
| Sum.....                      | 100.596          | Sum.....                     |                  | 98.168           |
| Oxygen Equivalent to Chlorin. | 0.474            | Excess of Sodic Oxid.....    |                  | 1.954            |
| Total.....                    | 100.122          | Total.....                   |                  | 100.123          |

TABLE XVIII.—ANALYSIS OF ALKALI FROM SOIL A, JULY 5, 1897.

|                               | <i>Per cent.</i> |                              | <i>Combined.</i> | <i>Per cent.</i> |
|-------------------------------|------------------|------------------------------|------------------|------------------|
| Silicic Acid.....             | 0.129            | Calcic Sulfate.....          |                  | 3.323            |
| Sulfuric Acid.....            | 52.127           | Magnesian Sulfate.....       |                  | 29.059           |
| Carbonic Acid.....            | 0.488            | Potassic Sulfate.....        |                  | 0.580            |
| Chlorin.....                  | 5.574            | Sodic Sulfate.....           |                  | 54.217           |
| Potassic Oxid.....            | 0.315            | Sodic Chlorid.....           |                  | 9.198            |
| Sodic Oxid.....               | 29.785           | Sodic Carbonate.....         |                  | 1.177            |
| Calcic Oxid.....              | 1.369            | Sodic Silicate.....          |                  | 0.262            |
| Magnesian Oxid.....           | 9.684            | Aluminic and Ferric Oxids... |                  | 0.111            |
| Aluminic and Ferric Oxids...  | 0.111            | Manganic Oxid.....           |                  | 0.101            |
| Manganic Oxid.....            | 0.101            | Ignition.....                |                  | 1.571            |
| Ignition.....                 | 1.571            |                              |                  |                  |
| Sum.....                      | 101.254          | Sum.....                     |                  | 99.601           |
| Oxygen Equivalent to Chlorin. | 1.256            | Excess of Sodic Oxid.....    |                  | 0.396            |
| Total.....                    | 99.998           | Total.....                   |                  | 99.997           |



These analyses are sufficient to show how very different the percentages of the various salts are in the alkali, and in that portion of the soil which is soluble in water. The latter contains a relatively small amount of sodic sulfate, the former a large amount. The sodic sulfate, together with the magnesian sulfate, is concentrated in the alkali.

#### FORMATION OF ALKALI INCRUSTATIONS EXPLAINED.

§ 82. The formation of these incrustations effects a rough separation of the markedly efflorescent salts, sodic and magnesian sulfates, from the permanent calcic sulfate. Ordinary salt, sodic chlorid, which is present, is also concentrated in the alkali, but not nearly to a like extent, as those already named. The highest figure obtained for the sodic sulfate in any sample of the water-soluble is in the first two inches of soil designated as B, in which it amounts to 27 per cent. In the alkalies it is practically 54 per cent., or twice as much. The highest percentage of magnesian sulfate in the water-soluble is 24 per cent., found in the first two inches of the soil C, while the average for the two samples of alkali is 28 per cent. The decrease of the calcic sulfate from the amount present in the water-soluble to that present in the alkali, is more marked than the increase in the sodic sulfate in the alkali given above. The minimum of the calcic salt found in the water-soluble is 34 per cent., the maximum 67 per cent., while the amount in these alkalies are 7.5 and 3.3 per cent., respectively. These relations show us the deportment of these salts when present in the soil solutions, whose surfaces are brought up and exposed to the evaporating influences of the atmosphere and sun. It is quite a different matter when the free surface of the water in lakes and ponds is presented to the same. In this case there is simply an evaporation to dryness, and the residue represents the salts held in solution by the waters, whereas, in the efflorescing alkalies we have the chemical and physical properties of these salts playing an important, if not the most important part. The sodic sulfate is predominant in the alkali, not because there is more of it in solution in the soil, but because it is separated more readily at the surface of the solution than the calcic sulfate. Magnesian sulfate also passes out of the solution more readily than the calcic sulfate, not because there is more of it in the solution, but because its chemical properties are different and its deportment toward the dissolving water and the soil particles is different. This subject will be discussed more fully and facts given, when we consider the soil waters. I wish, however, to emphasize the fact that the efflorescent alkalies are quite different from the residues left by evaporating bodies of water; such residues seem to be intermediate between those obtained by evaporating ground waters to dryness and the salt brought to the surface by capillarity and separated as efflorescences on the ground.

## ALKALINITY OF THIS SOIL.

§ 83. Several attempts were made to estimate the alkalinity of the soil, but without satisfactory results. It was simply determined that they all reacted with cochineal and a properly prepared litmus solution, showing an alkaline reaction. This reaction was more decided when the moistened soil was placed on litmus paper and allowed to remain there for a few minutes. While the samples were all alkaline, none of them were strongly enough so to permit of its determination by a one hundredth normal acid solution. I was not at all satisfied as to the cause of the alkaline reaction, for the samples of soil which had been washed free from the sulfates still showed the reaction when placed on litmus paper.

## FREE AMMONIA IN THE SOIL.

§ 84. Though aware of the unsatisfactory results obtained in endeavors to make this determination, I thought that the peculiar character of our soil and the very frequent occurrence of similar soils in Colorado, would justify me in making the attempt.

§ 85. The samples were taken in their fresh condition, magnesianic oxid added, and after standing a short time, an hour or so, were subjected to distillation. Ammonia-free-water was used throughout this experiment. The disillate at first was rich in ammonia, and while it became poorer and poorer, it continued to give a decided reaction with Nessler's reagent for ten days, when the experiment was stopped. In the case of sample No. 3, the whole of the ammonia was given off in four days. Three samples, Nos. 1 and 3 from plots which had not received any manure, and No. 2 from a manured plot, were subjected to distillation. The results obtained were :

- No. 1. Ammonia in dry soil ---- 0.00962 per cent.
- No. 2. Ammonia in dry soil ---- 0.00765 per cent.
- No. 3. Ammonia in dry soil ---- 0.00367 per cent.

The persistency with which the ammonia continued to come over, showed that it was probably being formed during the distillation and was not originally present as free ammonia, or as ready formed ammonia salts. In order to obtain as much evidence as possible regarding the occurrence of free ammonia in this soil, a fresh portion of sample No. 1, was taken and subjected to distillation with the addition of ammonia-free-water alone. The distillation was, as in the previous cases, permitted to proceed very slowly until two and a half litres of distillate were collected. There were still traces of ammonia coming over. The ammonia obtained equalled 0.00211 per cent. of the dry soil. The comparatively abundant evolution of ammonia in the early stages of the distillation with magnesianic oxid, and the decided quantity yielded upon



distillation with pure water, prove the presence of both ammonical salts and free ammonia in this soil, and the samples show that the amount of them was not dependent upon the manure added to the soil one year previous to the time that they were taken. I interpret the formation of ammonia salts and free ammonia in this soil, as indicating unfavorable biological conditions. The sample numbered 1 in this series is from that section of the plot which I have described elsewhere as a paludal soil. Its reclamation was not at this time complete. I may be mistaken in this view, but I believe it to be the explanation, and that the larger quantity of ammonical salts and free ammonia were due to the greater resistance this soil had presented to the ameliorating effects of cultivation.

§ 86. The examinations made of the ground waters, not only strengthen but extend this view. The ground waters show not only ammonia, but large amounts of nitrites, indicating a probable reduction of nitrates in some zone of the soil. The presence of ammonia in the upper portions of the soil is probably the most suspicious of all of our facts, as it seems to indicate a slow oxidation, and brings the zone of denitrification to the very surface.

#### VOLATILE ACIDS IN THE SOIL.

§ 87. The conditions obtaining in this soil being such that acid fermentations might take place, an attempt was made to determine the quantity of such acids, if any were present. Two samples of soils were examined for volatile acids; one had received manure and the other had not. The sample which had received manure yielded volatile acids, other than hydrochloric, equal to 1.3 c. c. of one hundredth normal soda solution. The one which had not received manure yielded volatile acids corresponding to 10.30 c. c. of the soda solution. These are exceedingly minute quantities and their only possible value is a qualitative one, suggesting that one of the effects of the manure added was to lessen the amount of these acids in the soil by modifying the character of the changes taking place within the soil.

#### NITROGEN AND NITRATES IN THE SOIL.

§ 88. Less has been done with this subject than appears desirable. My excuse is, that I have tried to study this subject in connection with the ground water, rather than with the soil, because there is no material and permanent accumulation of the nitrates in the soil, where it receives water enough, either as rainfall or as irrigation, to remove them more or less nearly at the same rate at which they are formed in the soil.

§ 89. The samples in which the total nitrogen was determined are comparable in a general way only, owing to the fact that the

soil is very varying, and that the samples were not taken from the same places in the plot. This variability in the soil is shown with greatest certainty in the amounts of potash in the different samples, these amounts varying much more than can justly be attributed to analytical errors. The series of samples in which I have made such determinations may serve as a measure of the changes which the cultivation of this soil had effected in the time elapsing between the taking of the samples. The nitrogen determinations for the year 1897 have not been taken from the table of "Analyses of Soils, General Samples," but were made on special samples. The samples for 1899 are sufficiently described as manured and not manured, the manure having been applied in 1898, one year before the samples were taken.

TABLE XIX.—TOTAL NITROGEN IN THE SOIL.

| 1897.          | <i>Per cent.</i> | 1899.                   | <i>Per cent.</i> |
|----------------|------------------|-------------------------|------------------|
| Sample A.....  | 0.0920           | No. 3, not manured..... | 0.0935           |
| Sample B.....  | 0.0945           | No. 3, manured.....     | 1.1700           |
| Sample C.....  | 0.0829           | No. 2, not manured..... | 0.1355           |
| Sample D.....  | 0.0819           | No. 2, manured.....     | 0.1295           |
| Sample E.....  | 0.1382           | No. 1, not manured..... | 0.1316           |
| Sample F*..... | 0.1081           | No. 1, manured.....     | 0.1312           |

§ 90. The samples have been arranged in this table so that those representing the same general sections stand as nearly opposite each other as possible, but they are not identical.

§ 91. The samples were taken in the same month of the year, and, so far as seasonal influences upon the nitrogen content are concerned, are comparable. The water received in 1899 was greater than in 1897. The general effect indicated is an increase of nitrogen for the whole plot.

§ 92. No effort was made to follow the formation of nitrates in the soil from day to day, or from week to week, but the amount of this substance eliminated in the ground water was determined weekly for the seasons of 1897-98-99 and 1900. The nitrates have been determined in but a single series of soil samples, representing the first and second two inches of the soils which had received no manure. The water-soluble, analyses of which have already been given, was determined in the same set of samples. The results are given in parts per million of the air dried soil.

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\* Sample F is the subsoil.



TABLE XX.—NITRATES IN THE SOIL.

|                        | <i>Water-Soluble.</i> | <i>Nitrogen.</i> | <i>Nitric Acid.</i> | <i>Potassic Nitrate.</i> |
|------------------------|-----------------------|------------------|---------------------|--------------------------|
| A—First two inches.... | 39,314 0              | 7.075            | 31.746              | 50.930                   |
| B—First two inches.... | 7,513 0               | 36.062           | 161.814             | 259.598                  |
| C—First two inches.... | 20,544.0              | 12.326           | 55.308              | 88.730                   |
| D—First two inches.... | 8,000.0               | 19.200           | 86.152              | 138.214                  |
| A—Second two inches..  | .....                 | Trace            | Trace               | .....                    |
| B—Second two inches..  | 3,890.0               | 0.389            | 1.745               | 2.800                    |
| C—Second two inches..  | 8,130.0               | 1.626            | 7.296               | 11.705                   |
| D—Second two inches..  | 8,640.0               | 2.073            | 9.306               | 14.929                   |

§ 93. This indicates that, at the time these samples were taken, a very small percentage of the total nitrogen existed in the soil in the form of nitrates, and that the first two inches of this soil was at the time very much richer in nitrates than the second, also that different portions of the plot contained very different amounts of these salts.

#### DO SOIL SAMPLES ABSORB NITROGEN ON KEEPING?

§ 94. The most of the nitrogen determinations given in this bulletin were made on fresh samples, but occasionally we found it desirable to check a determination on an old sample, one that had been in the sample room for one or more years. The samples are kept with ordinary care, but not always sealed. The samples which suggested this question had been carefully stoppered and kept two years, but had not been sealed. In order to answer this question, a sample was taken and the nitrogen determined in duplicate. The remaining portion of the sample was dried as usual, bottled, corked and kept in the laboratory for fifteen months and the nitrogen redetermined in duplicate. The average of the first two determinations was 0.1058 per cent., that of the last two 0.1066 per cent. The difference is 0.0008 per cent., which is possibly to be attributed to analytical differences, rather than to the absorption of nitrogen in any form from the atmosphere of the laboratory. If, however, we accept the analytical results as correct, they show that the sample gained a quantity of nitrogen, due to increase of micro-organisms, corresponding to 28 pounds per acre, taken to a depth of one foot.

#### HUMUS IN THE SOIL.

§ 95. The humus in this soil is not especially low, as is the rule with our soils in general. The earlier determinations being slightly under one per cent., while the later ones average about one and one tenth per cent., a gain of about three tenths of one per cent. I thought that the physical condition of the soil and the presence of so large an amount of soluble salts would probably modify the character of the humus to a sufficient extent to cause some marked changes in properties or composition sufficient to justify its analysis. This was not found to be the case. The humus is very much like

other humus, and is much more like the humus of the Southern and Eastern States, as given by Hilgard, than the humus of the prairie soils of the arid regions, which are supposed to be rich in nitrogen, carrying, according to Hilgard and Jaffa, as high as 18.5 per cent.

§ 96. A quantity of soil was treated as usual for the preparation of humus, extracted with ammonia and the solution precipitated by acidulation with hydrochloric acid. The precipitated humus was washed and dried. It formed a black mass with a strong vitreous lustre and conchoidal fracture. Its reaction was acid with litmus. The precipitated humic acids alone were preserved. The portion soluble in dilute hydrochloric acid and water was neglected, as we thought to obtain the whole of the soluble humic substances by evaporating the ammoniacal soil extract to dryness and examining it, but it was found to contain so much ammonic chlorid that the results were unreliable. It seems to be a difficult matter to wholly avoid this error when handling larger quantities of soil. The results obtained indicate a very much higher percentage of ash in the ammoniacal extract than in the precipitated humus, but on the other hand a materially lower percentage of carbon.

The elementary analysis of the precipitated humus resulted as follows :

TABLE XXI.—ELEMENTARY ANALYSIS OF PRECIPITATED HUMUS.

|               | <i>Per Cent</i> | <i>Per Cent.</i> |
|---------------|-----------------|------------------|
| Carbon.....   | 41.787          | 45.727           |
| Hydrogen..... | 4.804           | 5.267            |
| Nitrogen..... | 5.536           | 6.051            |
| Oxygen.....   | 39.254          | 42.955           |
| Ash.....      | 8.619           | .....            |
| Total.....    | 100.000         | 100.000          |

I have deducted the ash and given the carbon, hydrogen, etc., in parts per hundred to make their quantitative relation more evident, not to indicate that they form a definite compound. It is noticeable that the percentages throughout are almost identical with those given for humocrenic acid obtained by precipitation as the lead salt from a solution prepared from a sample of Russian black earth.

HUMUS. AS A SOLVENT.

§ 97. The ash probably forms an integral part of this precipitated humus, that is, the humus carried this inorganic part in such a state of solution that it retained it when thrown down by the dilute hydrochloric acid. The total sulfur present equalled 0.44 per cent. of the precipitated humus, equal to one and one tenth per cent. of sulfuric acid (anhydrid). The potash taken into solution by the four per cent. ammonia equalled 0.385 per cent. of the humus dissolved. The ash obtained from the filtered am-



moniacal solution, by evaporation and incineration, is rich in lime, that from the precipitated humus contains only a very slight trace of it. The ash from both, the ammoniacal solution of humus and the humus precipitated from it, is relatively rich in phosphoric acid.

§ 98. We made an attempt to determine the ash carried into solution by the extraction with ammonia. The results were not satisfactory. The solutions were all filtered repeatedly, but owing to the intense color of the solutions we could not feel assured that some of the variations in our results might not have been due to a turbidity in the solution. Our results indicated roughly one per cent.; this is probably too high, but it suffices to show that a very considerable portion of the whole mass of soil is soluble in this ammoniacal humus solution.

§ 99. Authors have insisted upon the value of humus as a solvent for the inorganic constituents of plant food in the soil. Free ammonia and ammoniac salts are probably present in small quantities, as previously shown, and we have in the humus, dissolved out of the soil by a dilute ammonia solution, phosphoric acid, sulfuric acid, potash, lime, iron and an abundance of silicic acid, which are not only food for the cultivated plants, but also for the micro-organisms which we believe effect the change of the nitrogen in the humus into nitric acid, respectively into nitrates, rendering it also available food for the plants. This seems an important function to attribute to humus, amounting in but few instances to more than one and a half per cent. of the soil, and yet it is justified. Our method of treatment or extraction does not faithfully represent the soil conditions, and therefore exaggerates its importance. This is probably less true than it appears to be, for the acids and bases forming the salts of the soil are not in the fixed and quiescent condition in which we usually think of them. On the contrary, there are certainly as many, and possibly more, changes going on than there would be in a mixture of the same salts in simple aqueous solution, and we know that there would be many. We have seen that there is probably free ammonia and ammoniacal salts in the soil, both of which aid the humus in its action by favoring its solution. The phosphoric acid extracted with the humus was determined at the beginning of the experiment and again after three crops had been grown on the plot. The results are shown in the following tables of analyses.

#### SOME RESULTS OF THREE SEASONS' WORK.

§ 100. The plot had received but little cultivation before I began my experimentation with it, and was in such bad condition that a part of it was so good as useless for any agricultural purpose. That this was not due to any lack of plant food is indicated

by the chemical analyses and also by its subsequent deportment under cultivation.

§ 101. The analyses of the samples taken at the beginning of the experiment may be summarized as follows :

TABLE XXII.—ANALYSES OF SOIL AT BEGINNING OF EXPERIMENT.

| SOIL, SAMPLES TAKEN 1897. |                | Nitrogen.<br>Per Cent. | Potash.<br>Per Cent. | Phosphoric Acid.<br>Per Cent. | Humus.<br>Per Cent. | Phosphoric Acid<br>in Humus. Cal-<br>culated on Soil.<br>Per Cent. |
|---------------------------|----------------|------------------------|----------------------|-------------------------------|---------------------|--------------------------------------------------------------------|
| A ....                    | { Spring ..... | 0.0937                 | 1.495                | 0.112                         | 0.815               | 0.0384                                                             |
|                           | { Fall .....   | 0.0938                 | 1.528                | 0.086                         | 0.712               | 0.0333                                                             |
| B ....                    | { Spring ..... | 0.0882                 | 1.003                | 0.064                         | 0.945               | 0.0205                                                             |
|                           | { Fall .....   | 0.1022                 | 0.978                | 0.128                         | 0.910               | 0.0345                                                             |
| C ....                    | { Spring ..... | 0.0882                 | 1.443                | 0.081                         | 0.736               | 0.0296                                                             |
|                           | { Fall .....   | 0.1015                 | 1.457                | 0.115                         | 0.740               | 0.0396                                                             |
| D ....                    | { Spring ..... | 0.0959                 | 1.443                | 0.061                         | 0.660               | 0.0288                                                             |
|                           | { Fall .....   | 0.1083                 | 1.372                | 0.099                         | 0.846               | 0.0294                                                             |
| E ....                    | { Spring ..... | 0.1295                 | 0.876                | 0.070                         | 0.808               | 0.0486                                                             |
|                           | { Fall .....   | 0.1191                 | 0.936                | 0.138                         | 1.030               | 0.0537                                                             |
| F* ...                    | { Spring ..... | 0.1040                 | 0.854                | 0.054                         | 0.574               | 0.0384                                                             |
|                           | { Fall .....   | 0.0996                 | 0.750                | 0.122                         | 0.502               | 0.0334                                                             |

\* F is a subsoil corresponding to soil E.

§ 102. The samples, “Spring” and “Fall,” represented in the above table were not taken by the same person, nor were they taken so nearly from the same spot that they can be considered as duplicates, still the agreement throughout is as close as can be expected, except in the case of the phosphoric acid. The analyses were made by the same person, so that the personal equation is eliminated, but the differences in the phosphoric acid are great, varying from 60 to 126 per cent. of the lower percentage found. It is possible that this variation between the spring and fall samples may be in the sampling, either in the field or in the laboratory, but every care was exercised to get this entirely correct. Duplicate analyses were made on most of these samples and good agreement was obtained, so that after making every allowance for errors in the analytical work and in the sampling there is a difference in favor of the samples taken in the fall. That the whole of the phosphoric acid present went into solution, there can be no doubt. We have examined the insoluble residues obtained from these digestions and have been unable to find any phosphoric acid. I have no explanation to offer.



The only remnants of the crop which could have been present in the fall samples were the fine roots which we could not remove, and such leaves as might have fallen and decayed during the season, all others were removed from the field. With these explanations, we must abide by our results even if there is a difference of 126 per cent. in the amount of phosphoric acid in practically the same soil, sampled in the spring and fall of the same year.

§ 103. It is not a matter for surprise that samples taken three years later, after the refuse of several crops and a liberal amount of manure had been incorporated with the soil, should show differences, indicating an improvement in the soil. The subsoiling, deep plowings, and the continued cultivation, together with the fact that the ground was left thrown up into rather high and rough ridges during the winters, exposing the deeper portions of the soil to the effects of the winter seasons—all tend to mix and improve the soil; but there is only one thing which has added any mineral matter to the soil, that is the application of the manure, which was made to alternate sections of the plot, as has been stated elsewhere.

Samples taken in the autumn of 1899 gave the following results :

TABLE XXIII.—ANALYSES OF SAMPLES OF SOIL TAKEN IN 1899.

| NUMBER OF PLOT. |                     | Nitrogen.<br>Per Cent. | Potash.<br>Per Cent. | Phosphoric Acid.<br>Per Cent. | Humus.<br>Per Cent. | Phosphoric Acid<br>in Humus. Cal-<br>culated on Soil.<br>Per Cent. |
|-----------------|---------------------|------------------------|----------------------|-------------------------------|---------------------|--------------------------------------------------------------------|
| 3.....          | { Manured .....     | 0.1152                 | 1.1700               | 0.1343                        | 1.1000              | 0.0767                                                             |
|                 | { Not manured.....  | 0.0935                 | 0.9990               | 0.1215                        | 1.0500              | 0.0735                                                             |
| 2.....          | { Manured .         | 0.1295                 | 1.3030               | 0.1567                        | 1.0600              | 0.0607                                                             |
|                 | { Not manured .     | 0.1355                 | 1.0994               | 0.1695                        | 1.2550              | 0.0255                                                             |
| 1.....          | { Manured .....     | 0.1312                 | 0.9540               | 0.1215                        | 1.2800              | Lost                                                               |
|                 | { Not manured ..... | 0.1316                 | 0.8493               | 0.1727                        | 1.0900              | 0.0670                                                             |

These numbers, 3, 2 and 1, manured and not manured, do not correspond exactly to A, B, etc. The five sections A, B, C, D and E, were made into six sections to study the effects of manure upon the crop and soil. No. 3 manured corresponds to part of A, while No. 3 not manured corresponds partly to A and partly to B, and so on. The plot was 600 feet long, and the manured and not manured sections were each 100 feet long. The samples were taken from the middle of the respective plots at the end of the season and nine months after the application of the manure.

The results indicate an increase in the humus present, but the analyses do not show conclusively that this was due to the application of manure, though the indications are that it had a perceptible effect. The results in regard to the phosphoric acid are difficult to bring into harmony with the facts as recorded or with one another, but the general results are in the same direction as those obtained from the samples taken in the autumn of 1897, namely, an increase. The increase in the nitrogen is not very pronounced, but seemingly quite general. The most marked result, however, recorded in the last table is the increased extent to which the phosphoric acid present in the soil can be extracted with the ammoniacal solution of the humus. It is entirely out of the question to attribute this large percentage of the phosphoric acid found in the humus solution to any turbidity which, owing to the dark color of the solution, might have passed through the filter and escaped detection. I regret that I did not examine the hydrochloric acid with which the soil was washed to determine how much phosphoric acid was removed by it. An inspection of the table shows that from 14 to 60 per cent. of the total soluble phosphoric acid was found in the ammoniacal humus solution.

§ 104. If we recall the amount of nitrogen found in the precipitated humus, about 5.5 per cent., we will see that the observation made on the phosphoric acid is also applicable to the nitrogen, only in a different degree. The humus contained from 14 to 60 per cent. of the former, but 40 or more per cent. of the latter.

The manure which was applied to this soil was analyzed, the results, together with some observations on its effects, etc., are given in Bulletin 58, pp. 13, 18, 36, *et seq.*

The sulfuric acid was determined in the samples taken in 1899, giving for No. 3, manured and not manured, 1.320 per cent. and 0.350 per cent.; for No 2, 0.333 and 0.633 per cent.; for No. 1, 0.683 and 0.314 per cent. If we compute this into sodic sulfate, as we have done elsewhere, it will be seen that the sulfates have either been removed or carried down into the soil beyond the reach of our sample, and either is an improvement.

§ 105. The results of this experiment are readily recognizable in the improved condition of the soil. The figures given as representing the composition of the samples taken in the autumn of 1899, may be right or wrong, but the improvement in the soil is much more pronounced than any analytical results can indicate, and after all of our seeking after facts and explanations, we are fully satisfied that there is much in the aggregate effect, whether it has been produced by moisture, æration, frost or sunshine, that has escaped our analysis, and while it is perfectly patent, it is not subject to clear and definite formulation. The application of manure pro-



duced some effects which we have noted at some length in Bulletin 58, especially those upon the crop, and we have incidentally stated that the salts in the ground water were influenced by the same, but we have acknowledged an effect, by stating that it improved the mechanical condition of the soil, which we fail to explain, because we do not recognize in what this actually consists. There are certain bold features in this improved condition which we readily perceive, but we cannot tell to what agents this improvement is to be attributed, nor the degree in which any particular agent has participated.

#### ANALYSES OF SOME COLORADO SOILS.

§ 106. I append a table of hitherto unpublished analyses of some soils from this State. These analyses were made some years ago by Mr. Chas. Ryan, under the direction of Dr. D. O'Brine, my predecessor.

There is no description or data of any kind given with the analyses. The record does not even show the locality from which the samples came more specifically than somewhere within a Colorado county. As a matter of fairness, I feel it due to Dr. O'Brine to state that, according to my information, he is not at fault for this, but that, owing to a bit of mistaken economy, he was not able to take the samples as he wished to, and did not obtain the data, whose lack detracts so materially from an otherwise commendable piece of work.

§ 107. The history of some of the samples is known, but so far as the record shows, there is nothing to indicate whether the samples are of virgin or highly cultivated garden soils, whether they are samples taken from excavations in city streets, or have been scratched from between the rocks of the hills.

The presumption was, and ought still to hold, in spite of the few exceptions of which we have definite knowledge, that the samples fairly represent the virgin soils of the State. If they do not, it is to be regretted that this work has been done to such little purpose.

TABLE XXIV.—ANALYSES OF SOME COLORADO SOILS.

| COUNTY.         | Insoluble. | Silicic Acid, Sol. | Sulfuric Acid. | Carbonic Acid. | Chlorin. | Phosphoric Acid. | Potash. | Soda. | Lime. | Magnesia. | Ferric Oxid. | Aluminic Oxid. | Manganic Oxid. | Moisture. | Ignition. | Total. | Nitrogen. |
|-----------------|------------|--------------------|----------------|----------------|----------|------------------|---------|-------|-------|-----------|--------------|----------------|----------------|-----------|-----------|--------|-----------|
| Arapahoe .....  | 69.79      | 7.05               | 0.05           | 0.05           | 0.07     | 0.08             | 0.16    | 0.54  | 3.25  | 0.03      | 2.69         | 10.03          | ....           | 2.16      | 3.98      | 99.93  | 0.10      |
| Archuleta ..... | 72.48      | 4.05               | 0.13           | 0.54           | 0.04     | 0.20             | 0.26    | 0.35  | 1.31  | 0.08      | 2.29         | 9.90           | ....           | 2.79      | 5.45      | 100.56 | 0.19      |
| Baca .....      | 63.00      | 7.44               | Tr.            | 1.28           | 0.04     | 0.05             | 0.22    | 0.20  | 2.51  | 0.66      | 2.35         | 7.48           | ....           | 5.00      | 9.25      | 99.48  | 0.16      |
| Boulder .....   | 70.68      | 3.90               | 0.14           | ....           | 0.06     | 0.16             | 0.75    | 1.97  | 0.41  | 0.06      | 6.38         | 7.79           | ....           | 3.10      | 4.68      | 99.99  | 0.20      |
| Boulder .....   | 67.50      | 10.00              | 0.22           | 0.35           | ....     | 0.14             | 0.45    | 0.95  | 2.25  | 0.85      | 2.04         | 6.96           | 0.09           | ....      | 8.28      | 100.09 | 0.11      |
| Chaffee .....   | 69.01      | 5.06               | 0.39           | ....           | 0.02     | 0.05             | 0.17    | 0.95  | 2.60  | 1.14      | 1.57         | 10.31          | ....           | 2.33      | 6.33      | 99.95  | 0.26      |
| Cheyenne .....  | 72.57      | 6.14               | 0.63           | ....           | 0.03     | 0.04             | 0.30    | 0.25  | 1.02  | 0.56      | 0.22         | 8.88           | ..             | 2.80      | 7.16      | 100.60 | 0.13      |
| Clear Creek...  | 65.50      | 5.00               | 0.10           | ...            | 0.04     | 0.02             | 1.69    | 1.34  | 0.90  | 0.75      | 7.08         | 8.32           | ....           | 3.14      | 6.17      | 100.11 | 0.27      |
| Conejos .....   | 70.24      | ....               | 0.02           | 0.38           | 0.03     | 0.06             | 0.68    | 1.98  | 1.46  | 0.44      | 2.94         | 5.07           | ....           | 3.50      | 13.10     | 99.90  | 0.23      |
| Costilla .....  | 78.50      | 1.27               | 0.39           | 0.01           | 0.06     | 0.07             | 0.26    | 2.31  | 1.65  | 0.14      | 1.42         | 8.03           | ....           | 2.17      | 4.57      | 100.85 | 0.18      |
| Custer .....    | 59.85      | 2.33               | 0.63           | 7.55           | 0.02     | 0.02             | 0.49    | 0.37  | 9.39  | 0.83      | 1.24         | 1.58           | ....           | 1.81      | 12.96     | 99.07  | 0.11      |
| Delta.....      | 76.77      | 1.56               | 0.11           | 1.45           | 0.05     | 0.01             | 0.45    | 0.18  | 2.03  | 0.83      | 4.50         | 8.40           | ....           | 1.96      | 1.87      | 100.17 | 0.08      |
| Douglass.....   | 82.04      | 0.08               | 0.20           | 0.02           | 0.07     | 0.03             | 0.37    | 0.51  | 0.24  | 0.28      | 2.54         | 8.34           | ....           | 1.42      | 3.10      | 99.24  | 0.13      |
| Eagle .....     | 73.67      | 1.80               | ....           | 3.49           | 0.09     | 0.03             | 0.10    | 0.16  | 5.32  | 0.91      | 2.51         | 5.55           | ....           | 1.34      | 5.04      | 100.01 | 0.09      |
| Elbert.....     | 86.35      | 0.69               | 1.19           | 0.48           | 0.04     | 0.01             | 0.46    | 0.93  | 0.12  | 0.42      | 1.54         | 3.83           | ....           | 1.34      | 2.66      | 100.06 | 0.12      |
| El Paso . ....  | 74.37      | 2.13               | 0.06           | 1.68           | 0.05     | 0.01             | 0.20    | 0.70  | 0.28  | 0.21      | 1.97         | 10.57          | ....           | 2.23      | 5.52      | 99.98  | 0.23      |
| El Paso .....   | 79.35      | 5.35               | 0.42           | 0.31           | ....     | 0.49             | 0.35    | 0.30  | 0.65  | 0.25      | 1.25         | 4.25           | 0.08           | ....      | 7.09      | 100.15 | 0.20      |
| Fremont .....   | 74.65      | 2.70               | 0.49           | 0.46           | 0.06     | 0.04             | 0.49    | 0.12  | 1.49  | 0.29      | 3.75         | 10.90          | ...            | 1.49      | 2.97      | 99.90  | 0.07      |
| Garfield .....  | 72.68      | 5.20               | 0.44           | 0.21           | 0.06     | 0.14             | 1.38    | 0.63  | 0.71  | ....      | 2.07         | 8.27           | ....           | 2.82      | 5.32      | 99.93  | 0.16      |
| Grand .....     | 72.01      | 6.09               | 0.53           | 1.00           | 0.05     | 0.05             | 0.37    | 0.22  | 0.70  | 0.16      | 1.06         | 3.88           | ....           | 3.80      | 11.03     | 100.95 | 0.23      |
| Gunnison .....  | 67.00      | 5.51               | 1.46           | ....           | 0.05     | 0.01             | 0.75    | 0.86  | 2.05  | 0.58      | 2.86         | 10.24          | ....           | 2.30      | 6.21      | 99.98  | 0.13      |
| Jefferson.....  | 60.72      | 10.56              | 0.99           | ....           | 0.05     | 0.01             | 0.57    | 0.78  | 2.34  | 0.17      | 6.17         | 9.77           | ....           | 3.06      | 4.72      | 99.98  | 0.12      |
| Kiowa.....      | 70.53      | 7.36               | 0.41           | ....           | 0.03     | 0.06             | 0.27    | 0.31  | 5.67  | 0.02      | 1.55         | 7.35           | ....           | 3.55      | 2.92      | 100.03 | 0.24      |
| Kit Carson....  | 73.11      | 7.11               | 0.61           | 0.02           | 0.07     | 0.03             | 0.41    | 0.30  | 3.00  | 0.66      | 1.93         | 6.06           | ....           | 3.57      | 3.14      | 100.02 | 0.14      |
| Las Animas...   | 77.72      | 5.32               | 0.45           | 1.01           | 0.04     | 0.90             | 0.25    | 0.11  | 1.55  | 0.11      | 2.93         | 4.70           | ....           | 1.66      | 3.70      | 100.45 | 0.06      |
| La Plata.....   | 75.74      | 7.15               | 1.14           | ....           | 0.02     | 0.10             | 0.76    | 0.22  | 0.93  | 0.13      | 2.59         | 4.06           | ....           | 1.48      | 5.66      | 99.98  | 0.16      |
| Larimer .....   | 65.35      | 6.38               | 1.44           | 4.90           | 0.03     | 0.08             | 0.12    | 0.56  | 6.72  | 0.28      | 2.18         | 5.96           | ....           | 1.80      | 4.10      | 99.90  | 0.08      |
| Larimer .....   | 81.50      | 5.67               | 0.31           | 0.40           | ....     | 0.28             | 0.42    | 0.36  | 1.15  | 0.35      | 2.17         | 4.10           | 0.03           | ....      | 3.25      | 99.99  | 0.10      |
| Larimer .....   | 67.47      | 7.88               | ....           | 1.96           | 0.09     | 0.09             | 0.15    | 0.35  | 3.43  | 0.56      | 2.01         | 7.30           | ....           | 2.88      | 5.75      | 99.92  | ....      |
| Lincoln ....    | 78.43      | 10.74              | 0.36           | ....           | 0.03     | 0.15             | 0.24    | 0.71  | 0.48  | 0.50      | 1.79         | 3.90           | ....           | 1.17      | 2.00      | 100.50 | 0.12      |
| Logan.....      | 78.08      | 8.30               | 0.05           | ....           | 0.05     | 0.03             | 0.70    | 0.46  | 1.36  | 0.18      | 1.76         | 6.19           | ....           | 1.57      | 2.02      | 100.12 | 0.11      |
| Mesa ... ..     | 72.49      | 10.41              | 1.66           | 1.65           | 0.03     | 0.11             | 0.11    | 0.50  | 3.43  | 0.70      | 2.45         | 3.36           | ....           | 1.00      | 2.11      | 100.01 | 0.01      |
| Montrose .....  | 66.00      | 1.75               | 1.23           | 5.32           | 0.06     | 0.04             | 0.78    | 0.87  | 6.81  | 0.08      | 2.68         | 6.25           | ....           | 2.45      | 5.76      | 100.04 | 0.05      |
| Montezuma ...   | 77.60      | 2.98               | 1.35           | ....           | 0.06     | 0.05             | 1.29    | 0.55  | 0.38  | 1.49      | 2.13         | 6.56           | ....           | 2.64      | 2.93      | 99.99  | 0.09      |
| Morgan .....    | 84.94      | 2.04               | 0.39           | 0.06           | 0.05     | 0.04             | 0.56    | 0.86  | 0.19  | 0.05      | 0.99         | 5.53           | ....           | 1.33      | 2.67      | 99.60  | 0.16      |



TABLE XXIV.—ANALYSES OF SOME COLORADO SOILS—(Continued).

| COUNTY.        | Insoluble. | Silicic Acid, Sol. | Sulfuric Acid. | Carbonic Acid. | Chlorin. | Phosphoric Acid. | Potash. | Soda. | Lime. | Magnesia. | Ferric Oxid. | Aluminic Oxid. | Manganic Oxid. | Moisture. | Ignition. | Total. | Nitrogen. |
|----------------|------------|--------------------|----------------|----------------|----------|------------------|---------|-------|-------|-----------|--------------|----------------|----------------|-----------|-----------|--------|-----------|
| Ouray .....    | 55.12      | 6.55               | 0.97           | 6.54           | 0.05     | 0.19             | 1.95    | 0.48  | 8.16  | 0.27      | 1.86         | 10.85          | ....           | 1.48      | 5.69      | 100.16 | 0.13      |
| Otero .....    | 80.23      | 3.03               | 0.50           | 1.15           | 0.09     | 0.14             | 0.91    | 1.52  | 1.76  | 0.16      | 2.38         | 4.45           | ....           | 1.55      | 3.25      | 100.12 | 0.12      |
| Park .....     | 79.55      | 2.67               | 0.54           | ....           | 0.05     | 0.07             | 0.65    | 0.45  | 2.33  | 0.55      | 0.95         | 2.10           | ....           | 2.04      | 7.90      | 99.85  | 0.32      |
| Pitkin.....    | 70.50      | 3.95               | 0.85           | 3.16           | 0.03     | 0.08             | 0.46    | 0.81  | 2.27  | 0.28      | 2.89         | 4.60           | ....           | 2.54      | 7.62      | 100.04 | 0.26      |
| Phillips.....  | 73.43      | 4.00               | 1.86           | 1.98           | 0.04     | 0.25             | 0.15    | 0.75  | 1.45  | 1.89      | 2.31         | 5.68           | ....           | 2.96      | 3.78      | 100.53 | 0.08      |
| Prowers.....   | 69.90      | 8.10               | 0.60           | ....           | 0.03     | 0.09             | 1.69    | 0.54  | 1.44  | 0.79      | 2.78         | 5.94           | ....           | 2.65      | 5.79      | 100.36 | 0.13      |
| Pueblo .....   | 75.84      | 5.11               | 0.10           | 0.36           | 0.04     | 0.08             | 0.22    | 0.16  | 1.62  | 0.54      | 3.71         | 5.66           | ....           | 2.19      | 4.75      | 99.36  | 0.13      |
| Rio Blanco ... | 69.88      | 4.35               | 1.12           | 1.95           | 0.04     | 0.18             | 0.78    | 0.27  | 1.45  | 0.43      | 2.75         | 7.13           | ....           | 2.56      | 6.64      | 99.55  | 0.24      |
| Rio Grande ... | 76.03      | 4.64               | 0.67           | ....           | 0.09     | 0.09             | 0.90    | 0.77  | 1.55  | 0.95      | 5.40         | 5.09           | ....           | 1.48      | 3.00      | 100.66 | 0.09      |
| Routt .....    | 67.04      | 6.14               | 0.66           | ....           | 0.04     | 0.20             | 0.69    | 0.57  | 1.21  | 0.53      | 3.33         | 6.73           | ....           | 3.56      | 9.20      | 99.90  | 0.24      |
| Saguache ..... | 65.59      | 9.46               | 1.10           | ....           | 0.09     | 0.11             | 0.26    | 0.99  | 1.64  | 0.63      | 3.60         | 5.33           | ....           | 3.97      | 7.41      | 100.18 | 0.24      |
| San Miguel ... | 69.61      | 5.28               | 0.47           | 1.19           | 0.04     | 0.06             | 0.11    | 0.44  | 2.10  | 0.67      | 3.38         | 6.08           | ....           | 3.60      | 7.30      | 100.33 | 0.31      |
| Sedgwick ..... | 69.43      | 5.87               | 1.20           | 2.47           | 0.03     | 0.30             | 0.33    | 0.84  | 3.46  | 0.32      | 2.21         | 5.40           | ....           | 2.33      | 6.34      | 100.58 | 0.11      |
| Washington ..  | 73.33      | 6.80               | 0.41           | 1.02           | 0.02     | 0.05             | 0.56    | 0.16  | 1.04  | 0.28      | 2.01         | 5.56           | ....           | 3.56      | 4.75      | 99.53  | 0.12      |
| Weld .....     | 79.76      | 6.36               | 1.13           | ....           | 0.05     | 0.11             | 0.54    | 0.16  | 1.38  | 0.42      | 2.43         | 3.52           | ....           | 1.48      | 2.52      | 99.86  | 0.07      |
| Weld .....     | 78.17      | 7.75               | 0.26           | 0.28           | 0.05     | 0.31             | 0.38    | 0.30  | 0.97  | 0.40      | 3.01         | 3.96           | 0.04           | ....      | 4.42      | 100.26 | 0.13      |
| Yuma .....     | 67.90      | 5.31               | 1.03           | 0.11           | 0.02     | 0.29             | 1.53    | 0.84  | 3.43  | 1.15      | 4.88         | 7.55           | ....           | 1.43      | 4.83      | 100.30 | 0.07      |
| *Otero†.....   | 74.27      | 10.50              | 0.05           | 0.68           | 0.02     | 0.04             | 0.41    | 0.78  | 1.33  | 0.71      | 4.34         | 2.43           | 0.17           | 1.44      | 3.54      | 100.76 | 0.08      |
| Otero‡ ...     | 84.06      | 5.88               | 0.04           | 0.31           | 0.01     | 0.04             | 0.26    | 0.33  | 0.60  | 0.22      | 3.38         | 1.66           | 0.22           | 0.74      | 2.42      | 99.98  | 0.05      |
| Otero§ .....   | 78.22      | 9.87               | 0.06           | 0.27           | 0.02     | 0.02             | 0.01**  | 0.70  | 1.05  | 0.46      | 4.24         | 1.36           | 0.22           | 0.89      | 2.55      | 99.94  | 0.06      |

\* Analyses of melon soils from Fowler, taken Jan. 27, 1899, analyst F. C. Alford. Digestion with acid sp. gr. 1.115 for 10 hours.

† Humus 0.14. ‡ Humus 0.08. § Humus 0.10.

\*\* Examination of this sample shows very little feldspar in it.

## SUMMARY.

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§ 108. The "alkali" salts in the soils and waters of Colorado are essentially mixtures of the sulfates of lime, magnesia and soda.

§ 109. The soils of the eastern slope of the Rocky Mountains and of the plains lying to the east in Colorado, have in general a very similar composition, as shown by the composition of the soil mass.

The mineralogical composition of these soils is very similar, the principal variation being in the ratio of the quantities of the minerals present.

§ 110. The surface soils of this section of Colorado probably owe their mineral constituents to a common source, the schists and granites of the Colorado range.

§ 111. The feldspar, orthoclase, an almost universal constituent of our soils, serves as a source of potash and also of hydrous silicates under ordinary cultural conditions.

§ 112. The readiness with which the chemical reactions take place and their character, as indicated by the salts present in the ground waters, probably have a direct and important bearing upon the fertility of the soil. The loessial soils of the plains agree with the ordinary prairie soils in the chemical composition of their mass and in the general results of the agricultural analysis, but not in the mechanical analysis.

§ 113. The analyses of the whole soil mass and of the different portions of the fine earth, suggest important differences between the unchanged rock particles in the soil and the finer portions which have suffered change or are the products of alteration.

§ 114. The aggregate amount of soluble salts per acre whose movement is effected by the water falling on or supplied to the surface, or by its evaporation from the surface, is large; we make it nine tons in one instance. The application of water, irrigation, may carry the soluble salts so deep into the soil that a long time may be required for them to come near to the surface again.

§ 115. The chemical analyses give us no hint of the very great improvement which was effected in this soil by three, really four, years experimentation with it. Our question was one of conditions and not of composition, so far as its purely agricultural features were concerned.



§ 116. The water-soluble in the soil and the incrustations formed upon the soil are very different in composition.

§ 117. The incrustations are formed by the evaporation of water from the surface of the soil, which, owing to the deportment of the solutions of these salts toward capillary action, and the chemical instability of the hydrated salts themselves, effects their separation from the soil solutions.

§ 118. The water-soluble in the soil is not identical with ground water solutions, probably due to reactions dependent upon the relative masses, which react upon each other within the soil and during the extraction.

§ 119. The reactions near the surface of the soil are quite different from those more remote. This is indicated by the solutions yielded by samples taken to depths of two and four inches.

§ 120. There is, in the samples of soil examined, both free ammonia and ammoniacal salts, which we interpret as indicating unfavorable biological conditions, which view is materially strengthened by the nitrates in the ground waters.

§ 121. There is a significant gain in the total soil nitrogen during the time of the experiment, which may have been favored by, but was not dependent upon, the application of manure.

§ 122. The nitrates in the first two inches of this soil are from nine times to two hundred times as great as in the second two inches, corroborative of the suggested reduction in certain zones of the soil.

§ 123. Air dried soil samples can be kept for a year or more with ordinary precautions, without material change in their nitrogen content.

§ 124. The humus in this soil is nearly as abundant as in average Eastern soils, and we were unable to find anything about it markedly different from ordinary humus. It is unlike the humus of arid soils, in that it is not so rich in nitrogen as they have been found to be.

§ 125. The solutions of the humus carried relatively very large amounts of silicic acid, phosphoric acid, potash and lime. The precipitated humus did not carry much lime.

§ 126. The effect of the cultivation, manuring, etc., for three seasons, may be summed up by stating that the store of plant food in the surface soil, taken to a depth of ten inches, was actually increased. This, however, was the lesser part of the improvement, the greater part lay in the betterment of the general conditions, whose best features cannot be shown by chemical analysis, or expressed in any formula.

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Bulletin 66.

Sept., 1901.

# The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

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## RELATION OF BOVINE TO HUMAN TUBERCULOSIS.

G. H. GLOVER.

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## TUBERCULIN TESTS OF THE COLLEGE HERD.

B. C. BUFFUM.

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PLATE I. KATE—JERSEY COW, APPARENTLY HEALTHY, BUT BADLY DISEASED WITH TUBERCULOSIS.



# PART I.

## REVIEW OF THE ARGUMENTS OF THE RELATION OF BOVINE TO HUMAN TUBERCULOSIS.

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BY GEORGE H. GLOVER.

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The recent test of the College herd with tuberculin and the consequent discovery of tuberculosis among cattle which were supposed to be in perfect health has led to some controversy; on the one hand by those who, because of their knowledge gained by actual observations and experiments, and who having been trained to think and reason to logical conclusions, are warranted in expressing themselves; and on the other hand by those who are not so warranted.

One thing in particular, more than any other, has inspired the issuing of this bulletin, viz: The evidence everywhere extant, that since the stand recently taken by Dr. Koch, there has settled upon the public a determined disposition to belittle the whole matter and throw precautionary measures to the wind. We urge upon all the warning that the difference between human and bovine tuberculosis has not yet been settled finally, and that precautionary measures for preventing the spread of the disease by butter and milk cannot be safely abandoned. It is one of the misfortunes accompanying the deliverance of such an uncompromising thesis as that by Dr. Koch that obscurantists of every dye make it responsible for conclusions which are not warranted by the facts in the case. It cannot be too strongly emphasized that even if it be proven that bovine tuberculosis is not communicable to the human race, the necessity for the most scrupulous cleanliness in the management of cows and their milk production is as great as ever. This incident coupled with the perfectly reliable information which we possess that a large percentage of the dairy cows in Colorado supplying milk to our towns and cities (especially the latter) are consumptive, and that it is yet far from proven that this disease is not communicable to human beings by the use of such milk; and further, lest the recent stand taken by Dr. Koch results in a criminal laxity or indifference: have together inspired the issuing of this bulletin. It is not claimed that we have made any new or startling discoveries: the work among the College herd, so far as it has gone, has in every instance corroborated our claims

(and which are in harmony with a great majority of the foremost investigators in this line of research) and the conclusions arrived at by reliable authorities are here compiled in as brief a manner as possible, hoping to accomplish something toward arousing the masses from their lethargy relative to the importance of this serious condition as affecting the animal wealth and the possibility of its being a prolific source of disease in the human family.

In the annual report of the Veterinary Science Department of the College, the assertion is ventured that the public in general in judging of veterinary science is prone to look upon it from a purely commercial (and in a lesser degree humanitarian) standpoint and do not take cognizance of its broader sphere of usefulness, viz: what the science is doing for the health and lives of the people themselves. It is in keeping with this thought that we venture a step further and assert that the educated veterinarians are among the leaders in the van now vigorously prosecuting the research that is being made in regard to the relation of human to bovine tuberculosis.

Tubercular consumption is one of the most dreadful and unfortunately, most common diseases of mankind. People of all ages or circumstances, and environments, regardless of climate, nationality, or degree of civilization, are subject to infection, if exposed under proper conditions. None are immune, and the present conditions prevailing, it looks as if we are doomed to become a sickly, consumptive race, and that its ravages must eventually almost wipe the human race from the face of the earth.

The greatest good to humanity will be accomplished along the line of preventing disease and while the prevailing medical thought now, both human and veterinary, is absorbed in new remedies, and is alive with keen expectancy as to the possibilities of sero-therapy, (which seems almost beyond conjecture) yet, after all, we must admit that prophylaxy (prevention of disease) is of vastly more importance than the discovery of new cures.

#### NOT A NEW DISEASE.

History from the earliest times has been replete with accounts of this "great white plague" and the theories advanced to account for its etiology and pathology have only been equalled in variety by the persistency with which they have gone wide of the mark.



At one period it would be considered contagious, at another this would be thought improbable, again several of the local manifestations of this disease would be looked upon as separate and distinct diseases; at other times it has been confounded with diseases that had no relation to it whatever. It seems strange, but it is nevertheless true, that while this disease has been known as affecting the lower animals, and a scourge in man (now claiming ten per cent. of the death rate) during all these centuries comparatively nothing was accomplished in working out its etiology or pathology until within the last fifty years Villimian and Koch have placed the matter on a sound basis.

### IS A GERM DISEASE.

Long before any suspicion existed as to the relation of bacteria to fermentation and disease, various scientists, at different times, had suggested that resemblance existed between the phenomena of certain diseases and fermentation, but the idea that a virus or contagium might be something of the nature of a minute organism, capable of spreading and reproducing itself, had never been thought of. The first vague notion in this direction was no doubt the ferment theory of Cagniard-Latour in 1828. In 1837, Schwann showed that fermentation and putrefaction were intimately associated with the presence of organisms derived from the air. By 1862 Pasteur had buried forever that "will-o-the-wisp" spontaneous generation and repeated and extended such experiments and proved the way for a complete explanation of the anomalies.

From 1870 onward the "germ theory of disease" had passed into general acceptance and now has become an assured fact, and in a sense has revolutionized the theories of disease and treatment in that now a persistent war is waged on the micro-organisms which excite the disease, and is not based altogether upon symptomology. Robert Koch first succeeded in demonstrating and isolating the specific bacillus of tuberculosis and achieved its artificial cultivation by the use of blood-serum.

### TRANSMISSIBILITY.

The origin of the germ theory of disease and the discovery of the specific bacillus of tuberculosis are but parts of an old story now relegated to history, but when we

look up the subject of the transmission of these germs from one animal to another, including man, we are at first surprised and then astounded at the seriousness of the conditions actually existing, and the grave possibilities which the tireless investigation by scientists may yet have in store for us.

### NOT CURABLE.

Favorable climatic influence will often stay the progress of the disease for a time at least, but no climate or therapeutical agent has ever been discovered which can in the true sense be called a cure. If ever anything is accomplished in either curing or preventing the disease it will most likely be in the direction of sero-therapeutics, but this is conjectural to say the least.

### RELATION OF BOVINE TO HUMAN TUBERCULOSIS.

That tuberculosis is transmitted from one animal to another, and more especially from the cow to other domesticated animals, has been repeatedly proven so that it is considered a waste of time now to rehearse them. The whole subject is summarized by Dr. John Repp in an article read before the Iowa Tuberculosis Convention in this way: "Enough has been done to prove beyond the peradventure of a doubt, that tuberculosis may be transmitted through the milk and the food structures of tuberculous animals, to the animals that consume these products or are inoculated with them, upon this all students of the subject agree. This much has been proven, but these facts do not decide the important question at issue, viz: whether or not tuberculosis is transmitted from animal to man, nor would they if they were multiplied ad infinitum, they only furnish a basis from which we may reason, for this purpose they are invaluable, as they establish the premise that the meat and milk of animals do, at times, contain living virulent tubercle-bacille."

If some of the incredulous will show the faith of their convictions by submitting themselves to a few "hypotheses" of bovine bacillus-tuberculosis, or by voluntarily injecting a few of the same, it will supply the last link in the chain of evidence necessary to convict the cow of transmitting the disease through her milk and meat to her human benefactors.

As there is little probability of anyone offering in good faith to sacrifice themselves for the cause of science, let facts



be submitted which, while circumstantial, are sufficient to lead us beyond the range of probability, to the very verge of absolute certainty. Our certain knowledge on the following may be analyzed as follows:

#### TRANSMISSION OF TUBERCULOSIS FROM ONE ANIMAL TO ANOTHER NOT INCLUDING MAN.

*1st, by Meat.*—Experiments, by their positive results, demonstrate that tuberculosis is transmitted in this way, both by artificial inoculation with the muscle juice of tuberculous animals, as well as by feeding the diseased tissue.

*2d, by Milk.*—This has been as fully demonstrated by a long series of experiments consisting of the inoculating of different animals with tuberculous milk, both from cows with diseased udders as well as those not so diseased, and further by the feeding of calves, rabbits, pigs, etc., with milk from tuberculous cows.

#### TRANSMISSION TO MAN.

There is, as previously stated, for reasons well understood, no opportunity to secure evidence by artificial methods. By natural methods the evidence consists of recorded observations, which have been made by close observers, covering a period of many years, of people who have used the milk and meat of tuberculous cattle. Dr. John Repp has gathered some statistics bearing on this point which are most interesting, as follows: "Oliver reports that in a young ladies boarding school, five girls, the children of healthy parents, died of tuberculosis of the intestines. The cow which had for many years supplied the school with milk was found to have generalized tuberculosis including the udder.

"Two daughters of a Scotch family of good health, who were brought up on milk of tuberculosis cows, died of tuberculosis. Two sons in the same family, who did not use the milk remained healthy." "Stang reports the case of a five-year-old boy of sound parentage and ancestry, who died of tuberculosis. The cow whose milk this boy used was found badly tuberculous." "Demme reports the case of four infants in the Children's Hospital at Berne, the offspring of sound parents, that died of intestinal and mesenteric tuberculosis. He was able to exclude all other sources of infection and to decide that they had been infected by

the ingestion of the milk of tuberculous cows." "Hills mentions the case of a child twenty-one months old of a friend of his, which drank the milk of a highly tuberculous cow for one week while on a visit to his uncle, and three months later this child died of intestinal tuberculosis. Other sources of infection could be excluded. A second child brought up on sterilized milk is still healthy." "Hills also reports the death of a boy four years old, at Yonkers, New York, from tubercular meningitis. The infection was traced to the milk of two cows of whose milk the boy had drank and which proved on autopsy to be tuberculous." "Ernest reports the death of three children of one family, from tuberculosis. These children had used the milk of a cow which later died of advanced tuberculosis including the udder.

"Stalker and Niles report that five persons, between twenty and thirty years of age of healthy ancestry, died of tuberculosis within a period of two years. On the farm where these deaths occurred they found seventeen cattle suffering from tuberculosis, and other cattle had previously died of this disease.

"Leonhardt reports the death from tuberculosis of the meninges, intestines and mesentery, of two children fed on the milk of a tuberculous cow. Sontag reports the case of a six-months-old child of healthy parents, which died of tuberculosis and which had been fed on the milk of a tuberculous cow. Hermsdorf has reported the case of a child, dead of intestinal tuberculosis, which had been fed on the milk of a tuberculous cow. Rich reports that a young man of healthy parents, who died of tuberculosis, had used plentifully of the milk of a herd of seventy-four cattle, sixty-five of which were tuberculous, some of them markedly so. Also another young man of the same family died of tuberculosis two months later. Rich destroyed eighty cattle out of the herd, that is about 90 per cent, of the entire herd. Also a young woman died of tuberculosis, and a month later the cows, whose milk she had used, died of advanced tuberculosis."

"Thorn reports that twenty-two physicians out of 339 practicing in Ohio, replied in the affirmative to the question, 'have you been able to trace any cases of tuberculous disease to the milk of unhealthy cows?' and that thirty-three replied in the affirmative to the question, 'Have you had reason to suspect the origin of tubercular disease in older children or adults to be in the meat or milk supply?'



This series of experiments and observations has been selected from literature with the greatest care, any reports which appeared not to be well authenticated or of a doubtful nature being excluded."

"Further circumstantial evidence is at hand in the fact that such large numbers of the bottle fed children die of the abdominal form of tuberculosis, and while, in some countries, the death rate of adults shows a marked decrease, the tuberculosis of children, and especially infants, is on the increase."

As previously stated, if we could but supply the one missing link, viz: whether the bacillus of tuberculosis is pathogenic for man, we would have our chain of evidence complete, and a positive demonstration would be our reward and the question would be no longer doubtful. The cases which I will now quote, from Dr. Repps' report, show conclusively that tuberculosis in the bovine species can be conveyed to man through one channel at least. "Tscherming, of Copenhagen, attended a veterinarian who had cut his finger in making a postmortem on a tuberculous cow. The wound healed but there still remained a swelling which soon ulcerated and refused to heal so that the whole tumefied mass had to be cut out. The microscope revealed the distinct tuberculous process and the presence of the characteristically staining bacilli." Pfeiffer attended at Weimar, a veterinarian named Moses, thirty-four years old, of good constitution and without hereditary disposition, who, in 1885, cut his right thumb deeply in making a post-mortem on a tuberculous cow. The wound healed, but six months later the cicatrix still remained swollen and in autumn, 1886, the man had pulmonary tuberculosis with bacilli in his sputa and death occurred in two and one-half years after the wound. Post-mortem revealed tuberculosis of the joint of the wounded thumb, and in the lungs extensive tubercles and vomicae." "Law reports that a young veterinary friend of his who was inoculated in the hand in opening a tuberculous cow, suffered from a tumefaction of the resulting cicatrix with tubercle-bacilli."

Rich reports that a man cut his finger on a spicule of bone, while making a post-mortem examination of tuberculous cows, and that in a few weeks he developed a tuberculous joint, and a few months later showed unmistakable signs of phthisis.

Ravenel reports the case of a veterinarian who cut the knuckle of his finger while making post-mortem examina-

tion of a tuberculous cow. The wound healed badly, remained swollen and showed decided tendency to ulcerate. Removal of cicatricial mass was practiced the tissues sent to him for examination. They showed typical tubercular lesions with giant-cell formation.

"I am well acquainted with this case myself and believe it to be an undoubted case of direct transmission of tuberculosis from cow to man by inoculation. This veterinarian told me that he did not become alarmed about the wound on his finger until he noticed a swelling and tenderness of the lymphatic glands on the muscle of the elbow."

The statistics gathered on this point are not many, but are exceedingly valuable as far as they go.

### **BOVINE TUBERCLE MORE VIRULENT THAN THE HUMAN VARIETY.**

From the scattered records of inoculation experiments, both early and recent, relative to the degree of virulency of of the tubercle bacilli of man and the bovine species, the conclusion arrived at I can best express by the following quotation: "To sum up the matter in a few words, it may be said that bovine tubercle has been shown to be more virulent than the human variety for cattle, sheep, goats and rabbits, while no distinction has been shown in the case of horses, pigs, cats and dogs.

### **DOMESTIC COW THE NATURAL HARBINGER OF THE BACILLUS TUBERCULOSIS.**

Dr. G. A. Johnson, in an article read before the Sioux Valley Medical Association, takes the position that in the bovine species we have the natural hosts of the bacillus tuberculosis. His argument is so fair and altogether unique that while it is entirely foreign to the prevailing idea of the medical fraternity, it is certainly worthy of serious consideration. He states his proposition in this way. "Tubercular lesions, wherever found, are the direct results of the action of the tubercular bacillus; and further, that the domestic cow is the natural harbinger of this bacillus; or in other words, tuberculosis was primarily a disease of the bovine species and is found in man and other animals as a result of transmission brought about through the ability of the tubercular bacillus to adapt itself to the various conditions as found in the various animals.



He reasons from analogy that a careful study of the geographical distribution of tuberculosis reveals the fact that all people who use the milk and flesh of the domestic cow (the        and inbred cow) as food products are more or less afflicted with tuberculosis, and further, that there is usually a very uniform ratio between the quantities of such foods consumed and the prevalence of the disease among the people.

On the other hand all of those people who do not use the food products of the domestic cow are comparatively free from the disease.

Prof. E. F. Brush, M. D., of Mount Vernon, N. Y., states as follows: "This insidious and delusive disease is not the result of civilization as is supposed. Barbarous and semi-civilized races are afflicted as severely as many of the most advanced civilized races." Neither geographical position nor climatic conditions are a factor in the distribution of pulmonary phthisis. Every known part of the globe, with a few isolated areas excluded, is a habitat of the disease. After several years of close study of the affection and consulting all accessible statistics and the habits of the people where the disease prevails, the only constantly associated factor is found, in my opinion, in the inbred bovine species without any regard to the social position of a community or its geographical habitation, terrestrial or atmospheric condition. If a community is closely associated with inbred cattle, tuberculosis is prevalent. In the fifteenth annual report of the State Board of health of New York, is found the following: "Human tuberculosis is co-extensive with bovine tuberculosis. Broad generalization of our laws and knowledge gives a close parallelism between the numbers of dairy cows and the prevalence of tuberculosis in the human race. Countries that have few or no cattle, or in which the herds are mainly kept in the open air, and are therefore largely protected from the disease show, as a rule, little tuberculosis in man."

Dr. G. A. Johnson, in substantiation of his argument, has found the conditions prevailing in different countries relative to this matter as follows:

*Europe*—Cattle have existed and tuberculosis has prevailed in man for centuries.

*Australia*—Tuberculosis was so rarely seen in early days as to lead to the idea that the climate was incompatible with the disease, but with the advent of cattle raising con-

sumption appeared among the people and has been gradually increasing.

*New Zealand*—Among the native Maories phthisis was unknown previous to the settlement of the English, and they possessed no cattle, but since that time tuberculosis has become a veritable scourge. Hirsch has said, "In my opinion the death rate from phthisis will keep on increasing in that locality if the breeding of cattle is not properly regulated by law."

*South Africa*—The coast tribes of Africa have been inbreeding cattle for centuries, and the natives have been tuberculous, while the tribes in the interior have had no cattle, because of the Tsetse fly which stings and kills them, have always been free from consumption.

*Madagascar*—The flesh and milk of cattle has been the principle diet of the native and they have been severely afflicted.

*North American Indians*—The native American Indians were always free from consumption until Uncle Sam began dealing out meat and cattle to them. Their habit of eating any and all parts of the carcass, often without cooking, has aggravated the conditions for the most favorable transmission of the disease and they have become consumptive.

*The Esquimaux*—Dr. Johnson has well expressed it when he says, "The Esquimaux has his dogs and reindeer, but no tuberculosis, while the Indian has his dogs and beef and is seriously afflicted with tuberculosis." On the other hand, it is found that the Indian is no more susceptible to the disease than is the Esquimaux, for when the latter is brought in contact with the white man and his cow he readily contracts the disease, etc.

*Italy*—The people are tuberculous, notwithstanding they have one of the balmiest climates of the earth.

*China*—Notwithstanding their dense population, consumption is rare, because the lower classes, which constitute the mass of the population, get very little or no meat or milk. And so he goes on with a review of the different people of various countries and islands of the globe, showing in each and every instance that those people who use the milk or meat of cattle are consumptive and just in proportion as they use said products and those who do not possess cattle at all are entirely free from it.

*Climate*—Immunity does not exist in any climate, or among any race of people. And while high and dry



climates like Colorado are beneficial in staying the progress of the disease, yet it prevails in various sections from the torrid to the frigid zones.

*Altitude*—Altitude has nothing to do with the distribution of the disease, for we find it from the sea coast to the regions of the highest mountains. Dr. Johnson says that "certain peoples inhabiting the Dead Sea basin, which is between 100 and 200 feet below the sea level, are free from tuberculosis, whereas it is more or less prevalent among most people inhabiting the mountainous regions of Europe and America."

*Civilization*—The disease does not follow in the wake of civilization, for some of the savages and semi-civilized races are seriously afflicted.

*Density of Population*—As previously indicated, China and India, two of the most densely populated countries, are comparatively free from tuberculosis, and in many of the rural districts of Europe and America the disease prevails.

*Filth and Poor Sanitation*—This has nothing to do with the distribution of the disease for we find it all the way from the wigwam to the palace. The fact remains that all these various conditions simply hasten to retard the morbid process, and not one of them can be said to be a constant factor in the distribution of the disease. The old argument of heredity has long ago fallen to the ground and been trampled to the dust, for new cases of consumption are constantly coming to view, where there cannot be traced any hereditary taint.

The only constant factor seems to be the milk and meat of the bovine species, and we certainly consider this argument worthy of serious consideration.

## CONCLUSIONS.

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1. The position taken by Dr. Koch is of inestimable value, whether right or wrong, as there has been nothing new but this conclusion placed before the medical and veterinary profession during the past decade, and it has aroused everybody from their lethargy and encouraged discussion and experiment as never before.

2. It is unwarrantable to assume that, because of the low virulence of human bacilli for cattle, that the reverse is true. It has been repeatedly shown that bovine bacilli are more virulent than the human. Bovine bacilli being easily transmitted to rabbit, horse, dog, pig and sheep, and in short, to almost every quadruped on which they have been tried, makes it highly improbable that man is not included in the list; and until this is disproven by actual experiment upon the human, it will not be wise to relax prophylactic measures.

3. Dr. Koch has been grossly misrepresented since his London Congress address. He says, among other things, 'I have one word and only one word to say, and that is what I said in London. That word is 'experiment!'" I would send it to my brother practitioners the world over. The time is past when we may be guided with either certainty or profit by statistics. Nothing short of actual dealing with actual conditions will avail. We demonstrated that human tuberculosis was incapable of transmission to cattle. We have now to lend ourselves to the reverse proposition.

"I did not mean to recommend the abandonment of comprehensive and expensive systems of regulation, prevention and inspection that is now in operation.

"We are well on the road to victory over consumption. The final triumph is denied only by those who are unwilling to sacrifice their hobbies and work together to the common end."



## PART II.

### TUBERCULIN TESTS OF THE COLLEGE HERD.

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BY B. C. BUFFUM.

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Our investigation of tuberculosis among the cattle belonging to the College is in line with what has been done by other Experiment Stations of prominence which have been doing live stock work. There is nothing startling or new, perhaps, in our findings, but we feel the matter is of much importance to the public. Dealing as it does, directly with our animal wealth and indirectly, perhaps, with the public health, it is well for the Station to give to the people of the state such information as we possess. We are not indulging in personal opinions or theories, but will confine our statements to what we believe are established facts. We believe it is high time that our agricultural communities should accept the situation, and dispassionately and intelligently take such wise action as will advance their own interests and, in all probability, alleviate human suffering as well.

So much has already been done to prevent and partially cure tuberculosis, that there is no longer excuse for allowing the disease unchecked progress either among animals or men. Tubercular consumption is now known to be a preventable disease and, contrary to the general opinion, it has been demonstrated that it is curable in a large per cent of cases or, at least, that the course of the disease may be checked for many years if taken in time and properly managed. It is probably true that there are over ten million people now living in the United States who are doomed to die of this dread disease unless something is speedily done to reduce the present death rate. This may be considered a fair statement of the present status and prevalence of human tuberculosis.

Cattle seem to be more subject to tuberculosis than any other representatives of the animal kingdom, but it is hardly possible to arrive at a correct estimate of the money loss to our agricultural interests from the bacillus tuberculosis. Coupled with these two items is the supposed relation of human and bovine tuberculosis. The disease in man

and in cattle has long been considered identical and in view of the many facts supporting such belief so well presented by Dr. Glover in Part I. of this Bulletin, it is well that everyone should understand the possible danger and take such precautions as will save money loss with stock, and protect against personal contagion. It is reported that Dr. Koch, before the London conference on tuberculosis, expressed the opinion that human and bovine tuberculosis are not due to the same germ. If reports are true, Dr. Koch believes that there is proof that human tuberculosis cannot be transmitted to cattle and, while not demonstrated, he thinks bovine consumption not transmissible to man. Dr. Koch discovered the true cause of tuberculosis and fully demonstrated the germ nature of the disease. He is one of the world's greatest authorities and his opinion should be given much weight. However, scientists are often misquoted and a simple statement of a failure to produce certain expected results in an experiment is twisted into a quotation from an authority, that it is an impossibility to produce the results. Newspaper misquoting and reportorial enlargement of scientists' statements are often mistaken for true science. It opens the way for ridicule and prejudice and does much to retard the acceptance of scientific facts. If Dr. Koch failed to transmit tuberculosis from man to cattle, or if he has discovered differences in the germs from animals and men which led him to doubt the identity of the two forms of the disease, it does not necessarily follow that the expression of this doubt is a statement of fact that there is one form of the disease in cattle and another in man and that they are never transmissible from one to the other. Dr. Koch thought that his lymph or tuberculin was a cure for tuberculosis. It was a wonderful discovery and a most important one, but because it failed to cure human tuberculosis is no reason for rejecting the careful scientific work of the man. The principle of using the toxin or poison produced by a germ to destroy the germ, or its power to live in the system, was established by Jenner when he introduced vaccination against smallpox and is successfully used as a cure of the disease in diphtheria. One of our state papers (The Eastonville World) takes a sensible view of the present statements of Koch, that he doubts the general infection of man with bovine tuberculosis, and points out the fact that we need not plunge into the use of unsanitary milk, butter and beef because a scientist has expressed such a doubt. Before



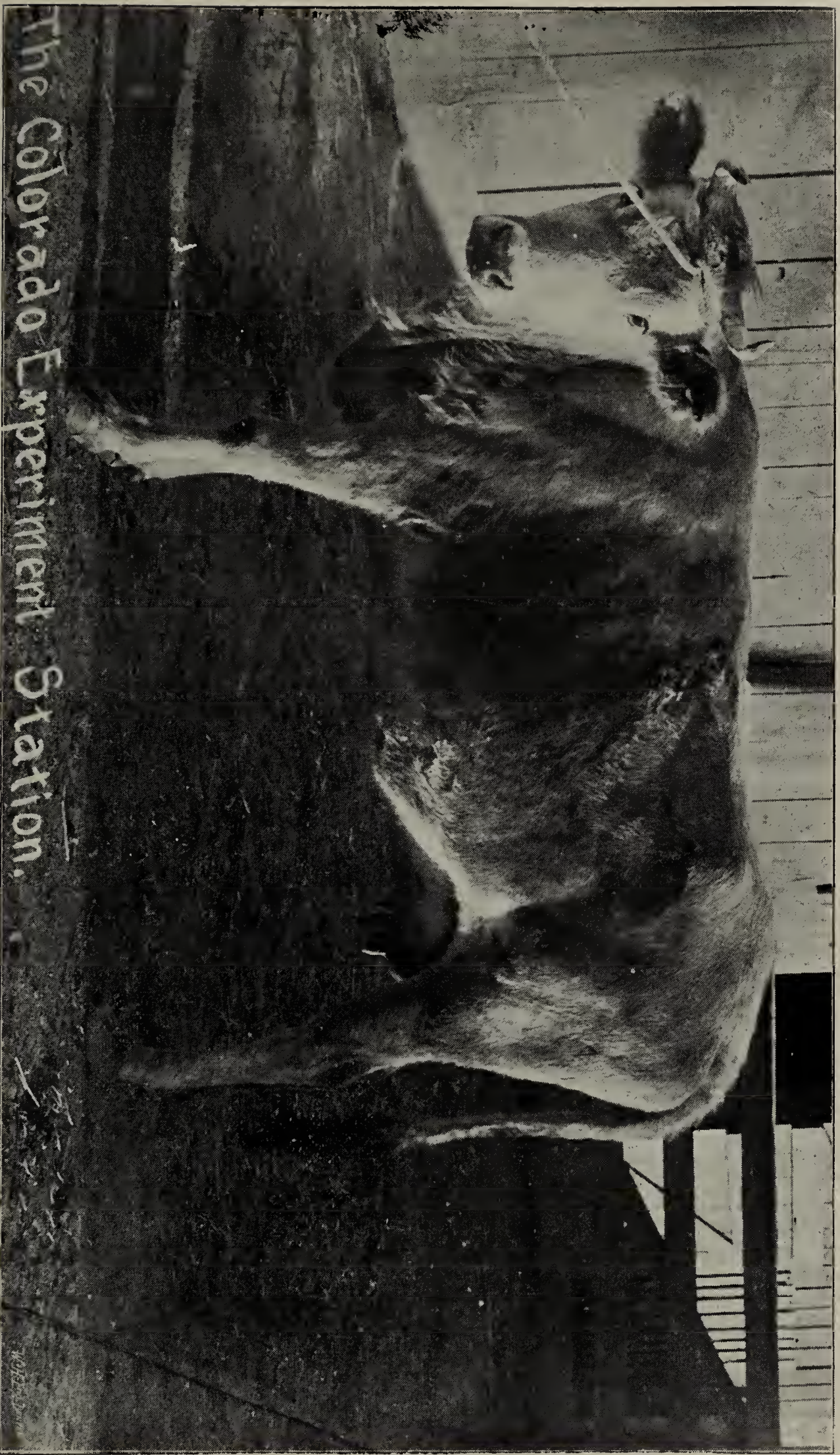


PLATE II. COUNTRESS LEE—JERSEY COW WITH GENERALIZED TUBERCULOSIS.





PLATE III. SECTION OF LEFT LUNG OF DISEASED COW FILLED WITH TUBERCLES AND CALCAREOUS DEPOSIT.  
SPLEEN OF DISEASED COW SHOWING LARGE TUBERCLES ON SURFACE.



leaving this part of the discussion let me state that there has been a large amount of scientific investigation which goes to prove that human tuberculosis can be transmitted to cattle by direct inoculation, and there is little doubt of its transmissibility from animal to animal or from one kind of animal to another.

If Dr. Koch's announcement is true, it is a most important discovery. However, so much evidence has accumulated to prove that men contract bovine tuberculosis that scientists are slow to accept this new theory of Koch's and will not do so without abundant proof.

The following quotations as made by the "Literary Digest" are of interest:

From the Philadelphia Press.

"The chief evidence of the transmission of tuberculosis from cows to human beings has rested on the cases of children. The strongest proof was summed in a report lately made to the British Medical Council that 'The mortality from tuberculosis in early childhood is not decreasing as at other ages, and the opinion that this is due to infection by milk appears well founded.'"

"Meanwhile, laboratory evidence accumulated that the human and bovine bacillus were not identical in shape, tests or increase. Cattle are relatively unsusceptible to human tuberculosis. It is extremely probable that Dr. Koch has carried this to full proof and developed the difference to be one of species. If, however, tuberculosis cannot furnish bacilli which gives human beings the disease, the cattle bacilli render cattle diseased. Infection once begun infects the entire herd. Unless people chose to eat diseased meat, and drink milk with bovine tubercle containing, as was found in Boston, 810 million germs to the tumbler, tuberculous cattle must continue to be sternly destroyed."

The following from the "Medical News" of New York:

"The belief that bovine tubercle bacillus is incapable of inducing tuberculosis in man is, of course, by no means new. For years there have been advocates of this side of the question. As a matter of fact, there is abundance of clinical evidence which indicates this capacity. Thus, Tscheving, of Copenhagen, in 1888, reported a case in point. The sufferer was a veterinary surgeon who wounded his finger while making an autopsy on a tuberculous cow. Local tuberculosis in the wounded part developed in a short time. Lefevre collected other equally striking examples which would be very difficult of explanation if our present view is incorrect."

The introduction to this report by Dr. Glover gives the above cases and presents abundant reason for suspecting tuberculous cattle. It will take nothing short of absolute proof to convince that bovine tuberculosis is not

dangerous to man. It is to be devoutly hoped that this is so, as it would greatly simplify the problem of ridding both man and cattle of the worst disease with which either is afflicted. Meanwhile, we should not cease using judicious caution and our researches are doubly interesting. The evidence against bovine tuberculosis has been sufficient excuse for all the laws and regulations enforced against it.

At the close of the British Congress on tuberculosis, before which Professor Koch delivered his paper, a series of resolutions were adopted, among which appears the following, as published in *Science*, Aug. 1901:

"That in the opinion of this Congress and in the light of the work that has been presented at its sittings, medical officers of health should continue to use all the powers at their disposal and relax no effort to prevent the spread of tuberculosis by milk and meat."

"That in view of the doubts thrown on the identity of human and bovine tuberculosis it is expedient that the government be approached and requested to institute an immediate inquiry into this question which is of vital importance to the public health and of great consequence to the agricultural industry."

There were over 2,500 members at this Congress including many of the world's foremost scientists.

#### THE TUBERCULIN TEST.

Within the past year the restrictions of this government on the importation of tuberculous cattle has given rise to vigorous protests on the part of men actuated by selfish interests. Our own people submitted to like restriction without complaint, but enforcing such regulations against Canadian cattle has given rise to what we believe are unwarranted attacks on the reliability of the tuberculin test which is used to determine whether or not cattle are tuberculous.

We think it unfortunate that some of our leading stock journals have published attacks on the test, which are calculated to mislead the public in regard to its efficiency and value. The highest authorities state that tuberculin is perfectly harmless to healthy cattle when properly administered as a test for tuberculosis. They are also agreed that it is a means of detecting the disease which is of great value and sufficiently accurate to be practically infallible. Because it gives fever to diseased animals or occasionally fails to produce its effect on such advanced cases that the disease can be found by physical examination does not seem sufficient



reason for condemning it as a diagnostic agent. It is believed that it does not fail to detect the disease in more than one-fifth of one per cent. of cases which are not far advanced in their course, and in our experience the disease has been found in every case which responded to the test.

Tuberculin is a glycerine extract of the toxin produced by the bacillus tuberculosis, but it contains no living germs which can communicate the disease. The normal temperature of an animal is obtained, then a small quantity of the tuberculin is injected hypodermically so it will be absorbed into the blood. If the animal is diseased the tuberculin causes a rise in temperature of 2 degrees or more in 8 to 16 hours, and sometimes a swelling and soreness where the injection was made. It should be used under the direction of a veterinarian or physician, or someone who has used and understands the method of applying the tuberculin and observing the results.

#### WHY WE TESTED THE COLLEGE HERD.

Our cattle had not been tested and we suspected the disease. However, we had only one animal under suspicion, and we hoped she would be the only case. Gildana, a Jersey cow about eight years old had been out of health for some months. She had the malignant catarrhal fever which was prevalent during the fall months, and did not recover as did other animals which were affected. She seemed to be passing into decrepid old age which we thought due in all probability to tuberculosis. Dr. Glover was consulted, and he agreed to test the dairy herd. We did not expect to find many cases as we thought there was reason to believe that tuberculosis might not be so prevalent in our dry sunny climate as it had proved to be in more humid regions. There may have been a little personal pride in the thought that our cattle, which had been given the best of care under the most favorable conditions, would be unusually healthy. As we will show later this idea was not without some foundation in fact. But tuberculosis is a disease which leaves its victim hopeful and in good cheer and one about which the novice should not jump at conclusions. We guessed that Gildana had tuberculosis, but we guessed wrong, for she did not respond to the test and is now believed to be healthy, while other cows in the herd which to all appearances were healthy, were found to be veritable pest houses of infection.

Again, because cattle form so large a part of human food; because they are subject to many diseases fatal to

man, and because cattle products, as milk and butter, are used in the raw state they are a constant menace to the public health. It is important then that the greatest care and sanitary precautions should be used in handling cattle and their products. Outside of the danger to man there is the item of financial loss from the presence and spread of disease among our stock. These are sufficient reasons for every cattle owner applying every test and attention which will insure keeping only healthy stock. Dr. Bang, the great Danish authority, has succeeded in having laws passed which makes sanitary precautions compulsory in Scandinavia, and already enough has been done in Europe to show that tuberculosis may be materially decreased by proper sanitary control of tuberculous subjects among both animals and man. In Denmark national laws make it compulsory to heat all milk to 185 degrees F. before it is sold, or before butter is made from it.

In Germany tuberculous persons are required to take the sanitary treatment prescribed and they find that tuberculosis is decreasing under these laws. Many of our states have legislative regulations for stamping out tuberculosis among cattle, and some of them are extreme in requiring the slaughter of all reacting animals. If human and bovine tuberculosis prove to be the same disease, it would seem that this method would be the surest and quickest way of removing the greatest of all dangers to human life, but because of the uncertainty, we are probably not ready at the present time to adopt such drastic and expensive measures. However, enough is known at the present time so no one is excusable for using milk or butter from cows which have not been given a bill of health and demonstrated free from tubercle, and no stockman is excusable for harboring and breeding the disease in his herd.

### RESULTS OF THE TESTS.

Three tests have been made of the cattle on the College farm, by Dr. Geo. H. Glover, veterinarian. The first on December 8, 1900, was of all the cows being milked in the dairy, consisting of seven Jerseys and one Shorthorn and also one Shorthorn which had lost her calf and had not been doing well for some time. Table I gives the result of this test, showing the normal temperatures determined before inoculation and the rise in temperature after injection. The maximum temperatures and total rise of reacting ani-



mals are shown in bold faced type. Unless the rise in temperature was more than 2.5 degrees it was not considered proof of infection. It will be seen that of the nine animals tested five, or 56.6 per cent. reacted.

TABLE I.  
TUBERCULIN TEST MADE DEC. 8, 1900.  
COLORADO AGRICULTURAL COLLEGE.

| No. | Name              | Breed     | Wt.<br>lbs. | Age<br>yrs. | Nrm'l<br>Temp. | Max'm<br>Temp. | Hours<br>after<br>injec'n | Rise in<br>Temp. | Remarks                                        |
|-----|-------------------|-----------|-------------|-------------|----------------|----------------|---------------------------|------------------|------------------------------------------------|
|     |                   |           |             |             | ° F            | ° F            |                           | ° F              |                                                |
| 1   | Young<br>Grannie  | Jersey    | 1072        | 10          | 100.1          | 101.5          | 11                        | 1.4              |                                                |
| 2   | King Lee<br>Noble | "         | 1122        | 4           | 100.7          | <b>107.1</b>   | 11                        | <b>6.4</b>       | Destroyed. Early<br>stages of disease          |
| 3   | Gildana           | "         | 920         | 10          | 100.3          | 101.2          | 13                        | 0.9              |                                                |
| 4   | Kate              | "         | 828         | 4           | 100.9          | <b>106.7</b>   | 11                        | <b>5.8</b>       | Destroyed Had<br>generalized tub-<br>erculosis |
| 5   | Lucy              | "         | 860         | 4           | 101.0          | <b>104.9</b>   | 11                        | <b>3.9</b>       |                                                |
| 6   | Lelia<br>Rose     | "         | 770         | 2           | 101.3          | <b>105.0</b>   | 12                        | <b>3.7</b>       | Destroyed. Dis-<br>ease not ad-<br>vanced.     |
| 7   | Gildana<br>2nd    | "         | 872         | 3           | 101.4          | 101.8          | 21                        | 0.4              |                                                |
| 8   | Orchard<br>Girl   | Shorth'rn | 1376        | 5           | 100.9          | 102.2          | 8                         | 1.3              |                                                |
| 9   | Ambrosia<br>2nd   | "         | 982         | 3           | 101.7          | <b>106.0</b>   | 8                         | <b>4.3</b>       | Destroyed. Gen-<br>eralized tubercu-<br>losis  |

The second test, principally of the Shorthorn cattle was made January 12. The results are given in Table II. No. 1, Young Grannie; No. 2, Lee Noble; No. 3, Gildana; No. 6, Lelia Rose; No. 7, Gildana 2d, and No. 11, Ambrosia, were cows which were injected during the first test. An interesting point and one which has been urged against the test is that the Jersey, Lelia Rose, and the Shorthorn, Ambrosia, which gave reactions at the first test on December 8, failed to react to this second injection of tuberculin. It merely illustrates the fact that an injection of tuberculin renders an animal immune to the test for some time after it has been made.

The time between tests of the same animal should probably not be less than six months, and the results of a test should not be accepted unless it is known that the animals have not been injected with tuberculin for at least six months time. Therefore we did not accept the failure to react at this second test as an indication of freedom from the disease and at the post mortem Ambrosia proved to be about as bad a case as could exist and the animal continue to live, although she appeared fairly well and thrifty.

Counting out the animals tested December 8, including

TABLE II.  
TUBERCULIN TEST MADE JAN. 12, 1901.  
COLORADO AGRICULTURAL COLLEGE.

| No. | Breed     | Wt.   | Age | Nrm'l Temp. | Max'm Temp.  | Hours after injec'n | Rise in Temp. | Remarks                                      |
|-----|-----------|-------|-----|-------------|--------------|---------------------|---------------|----------------------------------------------|
| 1   | Jersey    | 1072  | 10  | 100.8       | 101.9        | 12                  | 1.1           | Second test                                  |
| 2   | "         | 1122  | 8   | 101.4       | <b>106.5</b> | 18                  | <b>5.1</b>    | Destroyed. Had general-<br>ized tuberculosis |
| 3   | "         | 920   | 10  | 100.8       | 101.3        | 5                   | 0.5           | Second test                                  |
| 4   | Shorth'rn | 900*  | 2   | 102.2       | 103.3        | 9                   | 1.1           |                                              |
| 5   | "         | 1140  | 5   | 101.7       | 101.2        | 9                   | .....         |                                              |
| 6   | Jersey    | 770   | 2   | 101.1       | 103.0        | 11                  | 1.9           | Second test                                  |
| 7   | "         | 872   | 3   | 101.8       | 101.9        | 5                   | 0.1           | Second test                                  |
| 8   | Shorth'rn | 1225* | 3   | 102.1       | 104.0        | 13                  | 1.9           |                                              |
| 9   | "         | 1240* | 3   | 103.2       | 102.3        | 5                   | .....         |                                              |
| 10  | "         | 1260  | 3   | 102.4       | <b>106.3</b> | 13                  | <b>3.9</b>    |                                              |
| 11  | "         | 1250* | 3   | 102.8       | 102.2        | 21                  | .....         | Second test. Generalized<br>tuberculosis     |
| 12  | "         | 1050  | 3   | 102.2       | <b>106.1</b> | 13                  | <b>3.9</b>    |                                              |
| 13  | "         | 1190  | 7   | 102.4       | 102.3        | 9                   | .....         |                                              |
| 14  | "         | 1075  | 7   | 102.4       | 102.9        | 4                   | 0.5           |                                              |
| 15  | "         | 1320  | 4   | 102.6       | 102.9        | 4                   | 0.3           |                                              |
| 16  | "         | 1135  | 5   | 101.8       | 102.3        | 9                   | 0.5           |                                              |
| 17  | "         | 1300* | 4   | 102.7       | 102.5        | 4                   | .....         |                                              |
| 18  | "         | 1225  | 5   | 102.2       | 102.7        | 4                   | 0.5           |                                              |
| 19  | "         | 1275* | 4   | 102.2       | <b>105.8</b> | 15                  | <b>3.6</b>    |                                              |
| 20  | "         | 1650  | 2   | 102.5       | <b>106.5</b> | 15                  | <b>4.0</b>    |                                              |
| 21  | Jersey    | 800   | 1   | 101.6       | 103.0        | 12                  | 1.4           |                                              |
| 22  | "         | 805   | 1   | 101.8       | 103.6        | 10                  | 1.8           |                                              |

\* Estimates based on later weights.

TABLE III.  
TUBERCULIN TEST MADE JAN. 26, 1901.  
COLORADO AGRICULTURAL COLLEGE.

| No. | Breed     | Wt.   | Age | Nrm'l Temp. | Max'm Temp. | Hours after injec'n | Rise in Temp. | Remarks |
|-----|-----------|-------|-----|-------------|-------------|---------------------|---------------|---------|
| 1   | Jersey    | 1540* | 3   | 100.8       | 101.7       | 8                   | 0.9           | Bull    |
| 2   | Shorth'rn | 1000* | 2   | 101.9       | 101.0       | 11                  | .....         |         |
| 3   | "         | 1260  | 2   | 101.8       | 101.3       | 8                   | .....         |         |
| 4   | "         | 1270  | 12  | 102.5       | 103.9       | 21                  | 1.4           |         |
| 5   | "         | 1565  | 6   | 103.6       | 105.6       | 13                  | 2.0           |         |



those which reacted, there were 18 new ones tested January 12. Of the 18 animals, four, or 22 per cent. reacted. This does not include No. 8 which gave a temperature rise of 2 degrees.

While we had taken the temperatures of all the cattle, not quite enough tuberculin was obtained so a third test was made January 26. One Jersey bull and four cows were tested. (See Table III.) As none gave a rise of temperature of more than 2 degrees it was not considered sufficient to prove the disease in any of them.

#### SUMMARY OF REACTIONS.

A total of 31 head were injected with tuberculin and 10 reacted, or thirty-two and one-fourth per cent. There were 11 Jerseys, of which 5 reacted, or nearly 45.5 per cent. Out of 20 Shorthorns, 5 gave definite reactions, or 25 per cent., and 2 doubtful cases in which the temperature did not rise high enough to be considered proof of disease.

There were in reality two herds of Shorthorns. The old herd which had been raised on the College farm or had been here for 8 or 9 years did not contain a diseased animal while the 5 cases were out of a herd of 12 animals which had been brought from Iowa one year before the test. Then there was  $41\frac{2}{3}$  per cent. of the Eastern Shorthorns and none of the Western animals tuberculous. While this may have been an accident, we take it as significant, and probably it indicates what may be expected in a general way. It is generally believed that Western range cattle are practically free from tuberculosis.

#### POST MORTEMS.

Four of the reacting Jerseys and one Shorthorn have been killed and carefully examined. These examinations were conducted by Dr. Glover. In order to make the examinations as thorough and authentic as possible Dr. Glover secured the assistance and cooperation of Dr. L. Clark, a veterinarian of long standing and ability in the government employ, and Dr. R. McCarroll of Fort Collins. Mr. C. J. Griffith and the writer assisted with the work and took the notes. The College authorities were present to satisfy themselves that the disease was demonstrated and the class in veterinary science took an interested part. None of the cows had the disease far enough advanced to make it possible for the veterinarians to detect it by physical examina-

tion, but the diagnosis as made by the use of the tuberculin proved correct in every case and three of the five cows examined had generalized tuberculosis, i. e., nearly all the organs were diseased. In three of the four Jerseys examined tubercles were found in the udder where they were discharging into the milk. No attempt will be made to write a technical description of these post mortem examinations, but the following general notes will give the reader an idea of the amount of infection demonstrated:

*Kate.* (No. 4 in Table I.) Jersey cow, 4 years old. Reaction, 5.8 degrees. Killed and examined December 15, 1900. Carefully examined before death, but could find no evidence of disease. Cow in good condition with considerable internal fat. Had been lame and evidently suffering from effect of the injection of tuberculin since December 8. Lungs healthy except the lymphatic glands in the lungs which were hard and gritty with calcareous deposits in the tubercles. Kidney healthy, scattering tubercles size of pinhead to one-half pea, scattered over the intestines, especially the large intestine. Spleen covered with tuberculous growths. Liver with scattering tubercles and grit of small size all over surface and through the mass. Inside of womb and placenta along with umbilical cord covered with tubercles from size of grain of sand to small pea. Small tubercles found in udder. Photographs taken of cow and affected glands. Carcass burned.

*King's Lee Noble.* (No. 2 in Table I.) Jersey cow, four years old. Reaction, 6.4 degrees. Killed and examined December 29, 1900. Apparently in good health. Glands in lungs and those from the mesenteries affected, but not in advanced stage of disease. Well developed tubercles in the udder where milk glands were discharging over them. Photographs taken of cow before death, and of affected glands. Carcass burned.

*Lucy.* (No. 5 in Table I.) Jersey cow, four years old. Reaction, 3.9 degrees. Killed and examined December 29, 1900. Cow apparently healthy. All organs apparently healthy. Finally small glands from the mesenteries were found with well developed tubercles in the milliary stage. (Millet-seed like excretions of calcareous matter encysted in the glands.) Photographs taken before and after death, also of glands. Carcass burned.

*Lee Noble.* (No. 2 in Table II.) Jersey cow, seven years old. Reaction, 5.1 degrees. Killed and examined January 26, 1901. Though this cow was apparently healthy, inside of carcass and organs were found to be literally covered and filled with tubercles, the principal affection being in the liver, lungs, udder, lymphatic glands, placenta and umbilical cord. Hard, gritty, calcareous deposits everywhere. Carcass burned.

*Ambrosia.* (No. 9 in Table I and No. 11 in Table II.) Shorthorn cow, three years old. Reaction, 4.3 degrees. Killed and examined May 4, 1901. Cow apparently in good condition, well supplied with fat and with no external evidence of the disease. She had not been eating well for some time and we had been unable to get her with calf. Had a small tumor on right jaw. Post mortem demonstrated an advanced stage of tuberculosis. Ovaries and uterus badly diseased and filled with pus from the breaking down tubercles. Beside the sex organs, the spleen, liver and intestines,



along with lining of lungs and heart. were covered with surface tubercles. The lungs were very much affected, the left one being almost entirely filled with tubercles and calcareous déposits. Those who saw this dissection expressed surprise that the cow could be so generally diseased and continue to live, while in reality she had evidenced little outward sign of trouble. Photographs taken of spleen, glands and uterus. Carcass burned.

### REACTING ANIMALS NOT ALL DESTROYED.

It may be well to explain why all reacting animals were not destroyed at once. Some of them were kept for several reasons. In the first place it is a matter of some interest to determine whether tuberculous animals from the East will be cured of the disease by open air treatment when brought West. Second, it is considered possible to raise healthy calves from cows which are not badly affected, by separating them from the mother at once and putting them on nurse cows which are free from disease. Third, the cows will be useful clinical material for the instruction of students in veterinary science. The reacting animals are being kept away from healthy ones and as soon as our barn is remodeled and thoroughly disinfected we hope never to put a tuberculous animal in it. With every precaution against spreading infection the cattle will be handled for a time for experimental purposes. At the same time we will speed the day when we can say that our stock is free from disease and that there is no hereditary tuberculosis or tendency to it in any cattle at the College.

### CONCLUSIONS AND RECOMMENDATIONS.

1. While there is probably less disease in Colorado than among cattle from humid states, the disease is present in our herds and should receive attention.

2. Stockmen, especially dairymen and owners of family cows should get rid of the disease and not introduce more of it by the purchase of infected animals.

3. The tuberculin test is a reliable way of finding out whether cows are free from tuberculosis.

4. People should secure sanitary milk and disease-free butter, especially where children consume them. Milk or cream not from tested cows should be boiled before using. In ordinary practice any heat less than boiling should not be considered sufficient to kill the germs.

5. We do not know whether tuberculosis is commonly transmitted from cattle to man. The evidence that it is, as

presented in Part I of this bulletin is very strong. On the other hand so great an authority as Dr. Robert Koch thinks he has proved that human and bovine tuberculosis are different diseases.

6. In the state of our present knowledge of tuberculosis we can afford to take no chances by harboring infected animals, both because of the danger to ourselves and of the loss among our stock.

7. A cow may be seriously diseased so she will spread the infection to her calf or the rest of the herd and finally become unproductive and worthless herself without showing external signs of having a disease. The only known way of proving a cow healthy is by using the tuberculin test.

8. There is evidence to show that calves may inherit tuberculosis from their mothers, but it is generally considered that they are free from the disease when born and may be kept healthy by raising them on milk which is free from the bacilli.

9. Where apparently healthy cows which respond to the test are kept for raising calves they should be isolated and every precaution taken to prevent the spread of the disease to the rest of the herd. We found the sexual organs badly diseased in three out of five cows examined and do not think it would be safe to use the herd bull with them. In the writer's opinion the most profitable method is complete and conscientious destruction of diseased animals.

10. Cow stables should be regularly cleansed and disinfected. Good disinfectants are chloride of lime or a wash of equal parts carbolic acid and sulphuric acid mixed and diluted with twenty parts water. Sulphuric acid must be added slowly and carefully to the carbolic acid and these carefully to the water.



# The Agricultural Experiment Station

OF THE

Agricultural College of Colorado.

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## THE DISTRIBUTION OF WATER

### POWERS AND DUTIES OF IRRIGATION OFFICIALS IN COLORADO

BY

H. N. HAYNES.

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PUBLISHED BY THE EXPERIMENT STATION  
Fort Collins, Colorado.

# THE AGRICULTURAL EXPERIMENT STATION

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Under the Control of  
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# IRRIGATION ADMINISTRATION OF COLORADO.

1. *The State Engineer.*

Appointed by the Governor for a term of two years.

2. *Superintendents of Irrigation.*

One to each of the six water divisions. Subordinate to the State Engineer. Superior to the Water Commissioners. Appointed by the Governor, term of two years.

3. *The Water Commissioners.*

One to each water district. Subordinate to Water Superintendent and to the State Engineer. Appointed by the Governor from persons recommended by the several Boards of County Commissioners in the counties in which the water districts extend; term of two years.

The water districts consist of "the land now irrigated or which may be hereafter irrigated from ditches taking water from the following described rivers or natural streams of the State of Colorado."

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## WATER DIVISIONS AND DISTRICTS.

1. *The Platte, or Water Division No. 1.* Consists of all the water districts consisting of lands irrigated from the North and South Platte, Big Laramie River, North and Middle Forks of the Republican, Sandy and Frenchman Creeks and tributaries.

*Water Districts.* 16 in number. Nos. 64, 1, 28, 23 on the South Platte numbering from the State line; 3 on the Cache la Poudre; 4 Big Thompson; 5 St. Vrain; 6 Boulder and Coal Creeks; 9 Bear Creek; 46 and 47 North Platte (North Park); 48 Big Laramie; 65 Republican, Sandy and Frenchman Creeks.

2. *The Arkansas, or Water Division No. 2.* Consists of water districts of lands irrigated from the Arkansas River and its tributaries, Smoky Hill, South Fork of the Republican and Dry Cimarron.

*Water Districts.* 13 in number. Nos. 11, 12, 14, 17 and 67 on the Arkansas, in order down stream; 10 Fountain Creek and tributaries; 13 Grape Creek; 15 St. Charles; 16 Huerfano; 18 Apishapa; 19 Purgatoire; 49 South Fork of the Republican and Smoky Hill; 66 Dry Cimarron.

3. *The Rio Grande, or Water Division No. 3.* Lands watered from the Rio Grande and its tributaries.

*Water Districts.* (8). Nos. 20 and 24 Rio Grande; 21 Alamosa and La Jara Creeks; 22 Conejos; 23 Rio Grande and Costilla; 25 San Luis, Sand or Medano, Big and Little Spring Creeks; 26 Saguache; 27 Tuttle, Carnero and La Garita; 35 Trinchera.

4. *The San Juan, or Water Division No. 4.* Lands irrigated by San Juan River and its tributaries.

*Water Districts.* (6). Nos. 29 and 32 San Juan; 30 Rio Las Animas; 31 Los Pinos; 33 La Plata; 34 Rio Mancos.

5. *Grand River, or Water Division No. 5.* Lands in Colorado irrigated by the Grand River and its tributaries.

*Water Districts.* (20). Nos. 28, 39, 42, 45, 51, 53, Grand River; 36 Blue River; 37 Eagle; 38 Roaring Fork; 39 Grand, Elk, Rifle and Rhone; 40 Crystal Creek, Smith's Fork and Gunnison; 41 and 68 Uncompahgre; 42 Grand, Gunnison in Mesa County; 50 Muddy and Troublesome Creeks; 59 Gunnison; 60 San Miguel; 61 and 63 Dolores; 62 Gunnison.

6. *Green River, or Water Division No. 6.* Lands irrigated by water taken from the Green River and its tributaries.

*Water Districts.* (7). Nos. 43 White River; 44, 55, 51 and 58 Yampa; 54 Little Snake; 56 Green River.

## INTRODUCTORY.

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Every person who uses water in Colorado, whether for agricultural or domestic purposes is affected by the methods of distribution of the state, or by their application.

At least two sets of administrative machinery are required to deliver water to the consumer; one under the direction of the state officials provides for the division of water from the streams to the ditches and the protection of their various rights; the other, for the carriage and distribution of water from the head gates of the ditches to the consumer.

The machinery of the state is more particularly the subject of this bulletin. The methods of distribution to be followed by the ditches, and the duties of the ditch officials, are left to the ditches themselves. These are generally provided for in the by-laws of the ditches, or by custom. It is hoped to take up the division in ditches more fully in a future bulletin.

This bulletin consists of two lectures given by Hon. H. N. Haynes of Greeley, before the Short Course for Irrigation Officials, given at the Agricultural College in the spring of 1901. Their importance concerning one of the subjects which touches closely on the agricultural welfare of Colorado justifies a wider distribution.

They give a summary useful to every consumer and to the officials themselves on the powers and duties of the State Irrigation Officials, and aside from the intrinsic importance and the value of the views of a careful legal student, the information is widely scattered and difficult of access.

To those who have been acquainted with the development of Colorado irrigation law, Mr. Haynes needs no introduction. To others, it is sufficient to say that he was one of the first to represent the state as judicial referee in decrees relating to the appropriation to ditches. In the subsequent development of Colorado law on irrigation he has been actively concerned in the settlement of almost every question of importance brought for judicial determination in Northern Colorado; and a student of irrigation law in its broader aspects.

L. G. CARPENTER, Director.



# THE DISTRIBUTION OF WATER

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## POWERS AND DUTIES OF IRRIGATION OFFICIALS UNDER COLORADO LAWS.

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BY H. N. HAYNES.

It is the purpose of this paper to consider the powers and duties of state officials in distributing water. The American law of irrigation is yet in a formative state. It was unknown to the common law of England, from which we have borrowed the great body of our system of jurisprudence. It has been gradually building as the result of customs of the early settlers in the arid part of the United States, judicial decisions announced thereon, and the enactment of statutes, both by Congress and the several Territorial and State governments. Most of the decisions of the courts on irrigation subjects up to this time, have pertained to questions of appropriation of water from running streams, and from other sources of supply, and to controversies between rival ditch owners as to their relative rights, while comparatively little attention has been given to the matters now under consideration. So noticeable is the dearth of judicial decisions on the question of distribution of water by officials in charge, that in the two text-books on irrigation law, written respectively by Mr. Kinney and Mr. Long, the space devoted to the subject occupies but a very small fraction of the volumes.

In Long on Irrigation, which is divided into 15 chapters, but one chapter, the 12th, containing only four sections, is on the subject of public control of irrigation, and that chapter consists in the main of references to statute law. The space devoted to the same subject in Kinney on Irrigation, is about as limited.

It follows from the foregoing that little more can be said on the subject of the duties of the several water officials than to call attention to the statutes of the state prescribing their duties, to make some comments thereon with reference to practical questions likely to arise, to indicate the probable position which may be taken by the courts, and to suggest what line of policy and action should guide the officials under the statutes, to carry out their true intent and purpose, and so far as possible, to obviate the necessity of contentions and unnecessary litigation. It can readily be seen, it is difficult to go very far into this discussion

without traveling into ground which is somewhat open to controversy. The lack of authoritative judicial decisions on many questions likely to arise, is necessarily a source of embarrassment in making such comments from a professional standpoint.

#### EARLY LEGISLATION.

It is interesting to note that the first Legislature of Colorado Territory, on November 6, 1861, passed an act to protect and regulate the irrigation of lands, the fourth section of which, down to the proviso, reads as follows :

"That in case the volume of water in the stream or river, shall not be sufficient to supply the continual wants of the entire country through which it passes, then the nearest justice of the peace shall appoint three commissioners as hereinafter provided, whose duty it shall be to apportion in just and equitable proportion, a certain amount of said water upon certain or alternate weekly days to different localities, as they may in their judgment, think best for the interests of all parties concerned, and with a due regard to the legal rights of all."

The proviso of the section excepted from its operation land on what is known as Hardscrabble Creek, a tributary of the Arkansas. In the Revised Statutes of 1868, the same section was re-enacted, except that the Probate Judge was made the official to appoint the three commissioners, instead of the nearest Justice of the Peace. In 1870, by act approved February 11th of that year, that portion of said section 4, which referred to Hardscrabble Creek, was repealed. (Session Laws, 1870, p. 158, Sec. 1.)

In 1872, there was further legislation concerning the duties of the water commissioners in the County of El Paso. It was provided that they should receive \$5.00 per day when discharging their duties, to be paid by means of a tax levied by the County Commissioners, on each person using water for irrigation, in proportion to the amount of water used by each person.

In the second section of the act approved February 6, 1872, concerning irrigation in El Paso County, it was provided that the commissioners, with a due regard to prior vested rights, should establish such rules and regulations as in their judgment are necessary and proper to secure the purposes of the act, and to control the use of water for irrigation.

The third section of the act made it a misdemeanor subject to a fine and imprisonment, for a person to use water from any ditch or water course of the county to which he was not entitled, when the commissioners were controlling the same, or to hinder any commissioner in the performance of his duties.

A statute adopted February 9, 1872, applicable only to Pueblo County, required each ditch company to construct a tail ditch to return water with as little waste as possible, to the river, and made it unlawful to take more water into a ditch than was



necessary to irrigate the land under it when water was scarce in the stream. The second section amended the act of 1868, by substituting one commissioner for three commissioners. The third section required in Pueblo County, before a commissioner should be appointed by the Probate Judge, that a majority of the riparian owners on each stream, should sign a petition, requesting an appointment to be made, mentioning whom they preferred. (Session Laws, 1872, p. 144.)

The General Laws of 1877, which was a compilation of previous general statutes, as well as of those enacted by the first general assembly of the State of Colorado, contained the fourth section of the chapter concerning irrigation in the Revised Statute of 1868 without change, except that the words County Judge were substituted for the words Probate Judge. The compiler of the General Laws evidently overlooked the amendment of 1870, repealing the Hardscrabble proviso.

In the compilation known as the General Statutes of 1883, this important section of early Colorado law is printed with the amendment made in 1870, as Section 1714 thereof. It reads as follows:

"In case the volume of water in said stream or river shall not be sufficient to supply the continual wants of the entire county through which it passes, then the County Judge of the county shall appoint three commissioners as hereinafter provided, whose duty it shall be to apportion in a just and equitable proportion, a certain amount of water upon certain or alternate weekly days to different localities, as they may in their judgment, think best for the interest of all parties concerned, and with a due regard to the legal rights of all."

The same section was again printed in 1890 as Section 2259, of Mills Annotated Statutes.

Just how far any part of this old statute can be considered as now in force, may be a somewhat open question. Certainly the act of 1879, providing for the appointment of one water commissioner for each water district, constitutes an implied repeal of the power of the County Judge to appoint three commissioners; but whether the courts will or will not hold that the power "to apportion in a just and equitable proportion, a certain amount of water upon certain or alternate weekly days to different localities, as the commissioner may in his judgment think best for the interests of all parties concerned, and with a due regard to the legal rights of all," still vests in the water commissioner of the district, may be fairly debatable.

Further on we will consider this subject of apportioning water in time to different localities under the discretionary powers of the water commissioner, without reference to this statute. From any point of view, it is interesting to note that there has been legislative recognition of the wisdom of such alternate supply under certain circumstances of scarcity.

Prior to the year 1879, the system of dividing the water of running streams among the different ditches entitled thereto, was extremely crude. There had been no provision made to determine judicially or otherwise, except in the discretion of the commissioners, to how much water each ditch was entitled.

#### LEGISLATION NOW IN FORCE.

In 1879 the present Colorado system of adjudicating priorities and providing for the enforcement thereof, had its inception. It was attempted in that year, by the second general assembly, to provide a system of procedure to adjudicate priorities, but that part of the act of 1879 was found defective, and amended in 1881. In the act of 1879 ten irrigation districts were created, and it was provided that others might be created by the Governor, on petition of parties interested. Subsequent legislation has created new districts so there are now 69. The sixteenth section of the act provided for the appointment of one commissioner for each district, and the method of his appointment.

#### WATER COMMISSIONERS.

##### POWERS AND DUTIES UNDER THE STATUTES.

The 18th section of the act of 1879 (Section 2384 of Mills Annotated Statutes) defined the duties of the water commissioner as follows:

“It shall be the duty of said water commissioner to divide the water in the natural stream or streams of their districts among the several ditches taking water from the same, according to the prior rights of each respectively; in whole or in part to shut and fasten, or cause to be shut and fastened, by order given to any sworn assistant, sheriff or constable of the county in which the head of such ditch is situated, the head gates of any ditch or ditches heading in any of the natural streams of the district, which in a time of scarcity of water, shall not be entitled to water by reason of the priority of the rights of others below them on the same stream.”

In 1887, Superintendents of Irrigation were provided for and their duties prescribed. The 5th section of the act (Sec. 2451, M. A. S.), reads as follows:

“Each water commissioner shall report immediately to the superintendent of irrigation of his division, when he is called out, and when he ceases to be needed, and shall, during the continuance of his duties, be under the control of the superintendent of irrigation of his division.”

The 8th section of the same act (Sec. 2454, M. A. S.), reads as follows:



"Said superintendent of irrigation shall have the right to call out any water commissioner of any water district within his division, at any time he may deem it necessary, and he shall have the power to perform the regular duties of water commissioner in all the districts within his division."

In the 9th section of the same act (Sec. 2455, M. A. S.), each water commissioner is required to make reports to the superintendent of irrigation as often as required by him. Such reports of a water commissioner must contain information concerning,

(a) The amount of water needed to supply all ditches and reservoirs in his district, meaning of course, under each stream in the district.

(b) The amount of water coming into the district to supply such needs.

(c) Whether the water supply is on the increase or decrease.

(d) What ditches or reservoirs are, at the time of the report, inadequately supplied.

(e) The probability concerning the supply prior to the next report.

(f) Such other and further information as the superintendent of irrigation of that division may suggest.

Printed blank forms prepared by Superintendent of Irrigation would be helpful in the matter of such reports.

The 10th section of the same act of 1887 (Sec. 2456, M. A. S.) pertains in part to the duties of the water commissioners. It provides, in substance, that when any ditch or reservoir is not receiving its regular water supply, its owner may report such fact to the water commissioner of his district, who shall, if practicable, apportion the water in his district to aid the ditch mentioned, if he can do so, and shall, if necessary, by telegram report the situation to the superintendent of irrigation, to enable that official, if necessary and practicable, to supply the needed water at the expense of junior appropriators from some other district.

In 1889 an act was passed, the first section of which (Sec. 2293, M. A. S.) requires any person or corporation diverting water from a public stream, to erect and maintain headgates and waste gates in connection with his ditch, and provides that after five days' notice so to do by the water commissioner of the district or by the state engineer, if such headgates are not erected, then the same shall be constructed by the water commissioner, who is also vested with power to recover the expense thereof from the delinquent ditch owner.

The second section of the same act (Sec. 2294, M. A. S.) contains similar provisions, with reference to the keeping of suitable locks and fastenings on headgates where water is taken from a public stream, and on failure of the owner so to do, it is made the duty of the water commissioner to provide suitable locks and fastenings, and collect the cost thereof from the ditch owner.

By another act adopted in 1889, many important new duties and powers were thrown upon water commissioners. By its first section (Sec. 2386, M. A. S.), a water commissioner in discharging his duties is vested with the power of a constable, and is authorized to arrest any person violating his orders relative to the opening or shutting down of headgates, or the using of water for irrigation purposes, and to cause the offender to be prosecuted before a Justice of the Peace.

In a proviso to the same section, the orders of the superintendent of irrigation and of the state engineer shall be treated as superior to those of the water commissioner.

By the 3rd section of the same act (Sec. 2388, M. A. S.), the water commissioner is given power to employ a suitable assistant or assistants to aid him in discharging his duties. Such assistants are to take the same oath as the water commissioner, and to obey his instructions.

The 5th section of the same act (2391, M. A. S.), being a very important one, is here quoted in full, as follows:

"It is hereby made the duty of the water commissioner, after being called upon to distribute water, to devote his entire time to the discharge of his duties when such duties are required, so long as the necessity of irrigation in his district shall require; and it is made his duty to be actively employed on the line of the stream or streams in his water district, supervising and directing the putting in of headgates, waste-gates, keeping the stream clear of unnecessary dams or other obstructions, and such other duties as pertain to a guard of the public streams in his water district; and for willful neglect of his duty he shall be liable to fifty dollars fine, with costs of suit."

The 6th section of the same act (Sec. 2392, M. A. S.) provides that the water commissioner shall not begin his work until called on by two or more owners or managers or persons controlling ditches in his district, by written application, stating necessity for their action; it is also provided that the water commissioner shall cease to perform his duties when the necessity therefor shall cease.

In the same year, 1889, another act was passed imposing a penalty for the bribing of persons in charge of the distribution of water. This section (Sec. 2398, M. A. S.) makes it a misdemeanor for any water commissioner or his assistant to take or receive any money, promises or favors, or anything of value intended to influence him dishonestly to favor any person in the distribution of water to the injury of others.

In 1895 another statute was passed providing for the regulation of the use of the waters of the state. The same, consisting of three sections, is printed in the third, or supplemental volume of M. A. S., as sections 2384a, 2388a, and 2384b.

By the 1st section of the act (Sec. 2384a, Mills' Sup.), each water commissioner is empowered, and it is made his duty on



application of the owners of one or more ditches in his district, immediately to make or cause to be made, a thorough examination of all ditches within his district, to ascertain what use is being made by the consumers thereunder. If he ascertains that any ditch owner is permitting any water flowing in his ditch to be wasted, or to be wastefully, extravagantly or wrongfully used by its consumers, or put to any other use than that to which it is entitled to be used in its priority order, when needed by others, it is made the duty of the water commissioner immediately to shut off the supply of water in such ditch, to such an extent as in his judgment water was wasted, or wastefully, extravagantly or wrongfully used.

The 2nd section of the act (Sec. 2388a, Mills' Sup.) authorizes the water commissioner to appoint not to exceed two deputies to speedily make the examination provided for in section 1, just mentioned.

The 3rd section of the act (Sec. 2384b, Mills' Sup.) makes it a misdemeanor for any water commissioner to fail to perform the duties mentioned.

This act is one of special importance, increasing both the powers and duties of the water commissioners, and if properly executed will be of great benefit.

In 1897 an act was passed to regulate the exchange of water between reservoirs and ditches and the public streams, whereby, among other things, it was made the duty of any person or company transferring water from one public stream to another, to construct and maintain under the direction of the state engineer, measuring flumes or weirs, and self-registering devices, where the water leaves its natural watershed, and is turned into another, and also where it is finally diverted for use from the public stream.

The 3rd section makes it the duty of the water commissioner of the district where the water is used, to keep a record of the water so turned into his district from another.

The 4th section contains similar provisions as to delivering water to a public stream from a reservoir, so that the owner of the reservoir may take an equivalent amount higher up the stream in exchange. The section requires the water commissioner to determine and regulate this matter of exchange.

In 1899, by an act in relation to irrigation, a system of procedure in court is provided, in case a permanent change of the point of diversion of an appropriation is desired, to enable the court to determine whether the proposed change will be injurious to juniors or not. When a decree is entered in such a cause, a certified copy thereof is to be delivered to the state engineer, and that official thereupon issues a notice to the water commissioner of the district affected, notifying him of the

change made. Thereupon the water commissioner is required to allot the priority right to the new ditch, in pursuance of the new decree.

The 3rd section of the same act, permitting between ditch owners an exchange of water for a limited time to save crops, or to use the water more economically, provides for the owners making such loan or exchange, to give notice concerning the same, and thereupon requires the water commissioner to recognize the exchange in distributing the water.

No legislation of the Thirteenth General Assembly which has recently adjourned, affecting the duties of water commissioners has been brought to our attention.

#### COMMENTS ON POWERS AND DUTIES OF WATER COMMISSIONERS.

The foregoing compilation of legislative enactments defining the powers and duties of water commissioners makes it plain that the office is one of great responsibility and importance, requiring for the efficient discharge of its duties, to carry out both the letter and the spirit of the statute, constant attention, strict impartiality, energy, tact, hard work, and ability. From the very nature of the duties imposed, the fluctuations in supply of water during an irrigating season, the need of its use frequently being greater than the supply, considerable discretion must be exercised by the official in charge. It may be said at the outset that it is probably not possible, with the necessary limitations of human wisdom, for any water commissioner to attain perfection in performing these duties. But every faithful official should aim to attain as near an approach as possible to a perfect discharge of all the duties imposed upon him.

It is to be hoped that in the course of time, and with increased experience, the service will be improved; that mistakes and neglect of commissioners in the past and the injuries resulting therefrom, will occasion greater diligence and care, and more freedom from error in the future; that in time, the sooner the better, the selection of these officials will be removed more and more from the scrambles of politicians, so that a trained class of officials to perform these important duties necessary for the proper development of one of the leading industries of the state, will be evolved. In time, the demands of the irrigators of the state will be such that a faithful, conscientious and experienced official will be retained in office irrespective of the fluctuations in political control of the state government.

An effort will now be made to make some suggestions concerning the proper discharge of many of the duties of water commissioners prescribed by the statutes.



The principal duty of a water commissioner is that defined in the first statute whereby the office was created, tersely expressed in Sec. 2384, M. A. S.

“To divide the water in the natural stream or streams of his district, among the several ditches taking water from the same, according to the prior rights of each respectively.”

The language following the above in the statute, conferring power to shut down and fasten the headgate of any ditch not entitled to water is a mere incident to the language quoted.

The duty now under consideration involves consideration of the decrees whereby priorities have been judicially determined. Those decrees fix relative priorities of the several ditches in the stream in whose behalf evidence was introduced, the dates of such priorities, and the maximum amount of water under each priority to which the several ditches were then entitled. They do not provide that the maximum amount so defined under each priority shall be permitted to run into the ditch named at all times, irrespective of the necessities of consumers under the ditch. In most of the districts, perhaps in all, the decree defining priorities was made subject to several conditions, among which perhaps the most important was that which in substance stated that the decree should not be construed as adjudging to any claimant the right to take and carry by means of any ditch or reservoir, any water except to be applied to the use for which the appropriation was made, nor to allow any excessive use or waste of water whatever, nor to allow any diversion of water except for lawful and beneficial uses.

It is not the intention of the statute or of the decrees that the water commissioner, who is the executive officer to see that the decree and its provisions are enforced and observed, shall be permitted to ignore the limitations and conditions stated in the decree, and to deliver the maximum amount constantly throughout the irrigating season to a senior appropriator, or to deliver the maximum amount at any time when it is not actually needed for the necessary and beneficial irrigation of crops. In considering this general power and duty it is necessary also to discuss later statutes enacted for the purpose of emphasizing the importance of certain duties incident to the general power, and necessary to render the same effective. First among such provisions is the fifth section of the act of 1889 making it the duty of the water commissioner to devote his entire time to the discharge of his duties when necessary, and specially to be actively employed on the line of the stream to supervise the water delivery; to keep the same clear of unnecessary dams and obstructions, and to act as a guard of the stream. This requirement

of the statute demands the most constant vigilance. Many grave wrongs have been permitted on account of the failure of water commissioners to discharge this important duty. The writer's attention was called within the last two or three years to the fact that on one of the streams of the state for several years persons having ditches of quite late construction and without judicial decrees, had been taking water from sloughs and tributaries of the river, to the injury of early decreed appropriators on the stream, without any interference or action of the water commissioner to prevent such abuse.

It is manifestly the intention of the law that the water commissioner should act as faithful servant of all the appropriators on the stream, to see that their rights are protected under the judicial decrees. The administration of the water system of the state was provided by the legislature so that there should be some one person to act as agent for all, to see that their rights were respected, so as to obviate the necessity of farmers, busy with their agricultural work, employing a man to patrol the stream and to discover whether or not they were defrauded of their property rights. It is to be feared that there are too many water commissioners who are neglectful of the emphatic language of the statute requiring them to be constantly watchful. Too many commissioners wait to have complaint made to them of unlawful diversions, without themselves taking the initiative in such matters. It is evidently not the purpose of the statute that a water commissioner shall draw a fairly liberal per diem merely for giving orders concerning a few of the main ditches in his district, and waiting for some one to complain that a wrongful diversion is being made by a late ditch from some slough or tributary, or from the main stream itself, but that he should be actively concerned and have his assistants under his immediate supervision active to watch for abuses, and to prevent them, if necessary by the full force of the county.

It would seem that the statute mentioned was passed in 1889 to enforce greater vigilance on the part of the water commissioners. Three sections (Secs. 2386, 2388 and 2391, M. A. S.) were enacted for this purpose. The vesting a water commissioner with the power of a constable, and imposing upon him the duty of prosecuting for violation of his orders, and particularly the fifth section (2391 M. A. S.), making it his duty to be actively employed, supervising and directing putting in headgates, waste gates, etc., and acting as a guard of the public stream, and especially making it a misdemeanor subject to \$50 fine to willfully neglect this duty, indicates the legislature was led to believe that the previous general definition of his duty to divide the water according to the prior rights of all, was not found in practice sufficiently definite to bring forth the activity



needed. Everybody knows that the imposing of a penalty to follow a successful prosecution for neglect of duty, is not of itself very effective in many matters, because of the reluctance of citizens to institute such prosecutions, and of the difficulty of obtaining convictions. But the passage of such a statute should have great influence on faithful officials in calling their attention to what is expected of them under their oaths of office. It is sometimes unfortunately true that persons in public service are less disposed to make active and constant exertion than are those in the employ of private persons or companies. It is respectfully urged that the water commissioners of this state should each and all resolve not to fall into such careless habits, but to remember what is expected and demanded of them by the plain language of the law and by their official oaths.

Another duty specially imposed by statute in 1895, which is really only ancillary to the duty of apportioning the waters of the stream according to the prior rights of all, is that defined in Sec. 2384a, Mills' Supplement. The water commissioner is required, on application of the owners of any one or more ditches in his district, at once, thoroughly to examine the ditches under his supervision to ascertain what use of water is being made by consumers. Then if he ascertains the water under any ditch is being wasted, or is wastefully, or extravagantly or wrongfully used to the injury of other appropriators, he must shut off the water supply of such ditch to such extent as in his judgment the water was so wasted or otherwise wastefully or wrongfully used. As the greater includes the less, it is believed that if a ditch owner asks a water commissioner to make an investigation of some particular ditch and not of all of the ditches in his district, he should do so either in person or by a deputy. It will be noted that the third section of the same act of 1895 (Sec. 2384b, Mills' Supp.) makes it a misdemeanor for any water commissioner to fail to perform this duty. It may be further observed that it is certainly not improper, and in many instances it may be the duty of a conscientious official if his attention is in any way called, without formal complaint of a ditch owner, to the fact that water is being wrongfully and wastefully used under some particular ditch in his district, to make the investigation on his own initiative and prevent the abuse if he find it is taking place. It is further suggested that in any event when a water commissioner has reason to believe that any ditch with an early priority is demanding more water at a particular time than it really needs, or for the purpose of using some water for an improper purpose to the injury of some junior appropriator, he can keep fully within the law by advising the superintendent of irrigation of his belief that investigation of such ditch is necessary,

whereupon that official can give him special instruction to make the investigation.

While the power and duty now being considered is specially enjoined by statute and should, whenever necessary, be faithfully and fearlessly performed, it cannot be overlooked, that the power is one of a very delicate nature since it reposes very much discretion in the water commissioner, sometimes likely to be abused and even with the greatest care liable to result in litigation. Each water commissioner should endeavor practically to accomplish the end desired by adopting such a course, at least in the first instance, as will prevent the waste or extravagance complained of or suspected, through the pressure of persuasion and advice before resorting to more arbitrary and extreme measures. To illustrate: If a water commissioner has good reason to believe under some ditch in his district having a large early priority, when water is demanded up to the maximum amount called for by a decree, that with such delivery of water, a good deal is wasted, that the roads under such ditch are flooded, and other like indications of wasteful use are brought to his attention, it may be the part of wisdom for him, first to approach the superintendent or owner of such a ditch, and inform him of his reason to believe that the ditch should get along with considerable less water without anybody being injured, call his attention to the power and duty thrown upon the water commissioner under the statute, and request the superintendent or ditch owner for a few days to see how he can get along with a more limited supply. It is believed in many cases extravagant use of water, particularly that due to carelessness can be prevented, and the rights of junior appropriators in this way be protected without the water commissioner being compelled to go to considerable expense to adopt more rigid and arbitrary methods. However, in all cases when the commissioner finds it necessary, he should vigorously use all the powers given him by the statute to prevent such wasteful use of water.

Under the general power of distributing water with due regard to the prior rights of all, another general topic should be treated. So far as it is possible so to do, it should be the aim of the water commissioner to use the influence of his office to bring about the largest possible production of crops under all the ditches in his district. When he finds that crops are becoming parched and withered under some ditch he can properly seek to persuade owners of ditches having senior appropriations, who are not in very urgent need of water at the time, to make some concessions for the benefit of those in greater need.

In this connection, attention is again called to the early legislation of Colorado Territory, whereby commissioners appointed by the County Judge were required to apportion water



of the stream on alternate days to different localities as they may in their judgment think best for the interests of all parties concerned, and with due regard to the legal rights of all. Experience has shown in distributing water under the larger ditches with numerous consumers, at a time when the supply is limited, much better results are accomplished by delivering the entire available supply alternately, to a fraction of the consumers for one or two days, to other consumers, and so on, because with a better head of water better results can be obtained in a short time than with a small head in a much longer time. The same principle if permitted by law could probably be applied successfully in distributing water among different ditches when the supply in the stream becomes limited. It is, of course, a subject of grave doubt as to whether a water commissioner can alternate the supply in the manner suggested against the consent of the ditch owners affected thereby. But it is suggested, that such consent may be obtained in some instances through the exercise of tactful suggestions by the water commissioner upon the understanding that some benefit will result to the party making the concession, by means of a return concession in his favor later on.

To illustrate: We will suppose that there are two ditches each having a capacity of carrying 100 cubic feet per second, and that there are no other ditches to interfere with the arrangement; that ditch A has priority numbers 1 and 3 each for 50 cubic feet per second; that ditch B has priorities numbers 2 and 4, each for 50 cubic feet per second, and that the river at the particular time under consideration supplies only 100 cubic feet per second for the two ditches, we will say for a period of two weeks. It is evident under the circumstances stated that a strict compliance with the prior rights of the two ditches will give each of them 50 cubic feet per second during the time mentioned. Consumers under both ditches under those circumstances would derive benefit by authorizing the water commissioner to deliver 100 cubic feet per second to ditch A for half the time, and 100 cubic feet to ditch B for the remaining half of the time or on alternate days. It will be noticed that under this hypothetical case each ditch will get just as much water as under the other plan, but the probabilities are that the same amount of water will do very much more good if given in double the quantities for half the time.

The last section of the statute of 1899 confirming temporary loans or exchanges of water, was evidently adopted to apply to just such a case where two ditch companies themselves get together to make such an agreement and notify the water commissioner thereof. But it is here suggested that a water commissioner would be enabled in many instances to accomplish a great deal of good by himself taking the initiative and urging

the owners of different ditches to enter into such an arrangement at times of scarcity. He is familiar with conditions in the whole district, and can see what ditches can be best helped by such an arrangement with justice to all.

Human nature is such that men can be induced to do things by good tact and by persuasion of an official in charge, to which they will not submit under arbitrary exercise of power. It is perhaps unnecessary to state, to enable a water commissioner to accomplish the best results in the exercise of discretion and the use of persuasion, he must have the confidence of the ditch owners of his district as an official who is wholly disinterested and impartial, who is not seeking to aid any particular ditch to the disadvantage of another, but who is conscientiously striving to attain the best result for all the ditches in his district. To attain this confidence, he should have no favorites or pets, he should always show his readiness to respect the rights of senior appropriators; he should be vigilant in protecting the stream and all its sloughs and tributaries from invasions of persons who are wrongfully taking water therefrom. When owners of ditches with early appropriations have full confidence in a water commissioner, when they know that he has supplied them and is ever ready to supply when they really need it with all the water to which they are entitled, they will be much more ready at times when they are not in such urgent need to forego some of their claimed rights at his suggestion for the benefit of others whose crops are suffering. Under such circumstances the senior appropriators will readily acquiesce in suggestions made by water commissioners, believing that they will obtain a full equivalent for any concession they may temporarily make.

Another power or duty required of water commissioners worthy of some comment, is that mentioned in the fifth and ninth sections of the act of 1887 (Secs. 2451, 2455, M. A. S.) The last named sections call for reports to be made by the water commissioners to the superintendent of irrigation as often as required by him. It is to be observed that these reports are to contain not only the special matters mentioned in the statute, but also further information when called for or suggested by the superintendent of irrigation. A water commissioner has more direct and immediate knowledge of the conditions in his own district than does the superintendent of irrigation. Without abusing his power and in full compliance with the spirit of the statute, it is proper and desirable that water commissioners shall make frequent reports, and as the result of their experience make frequent suggestions to the superintendent of irrigation so that that official can study the whole problem in his whole division and make suggestions to other water commissioners helpful to bring about the best results of husbandry.



## SUPERINTENDENTS OF IRRIGATION.

## POWERS AND DUTIES UNDER THE STATUTES.

As we have already seen, the division of the irrigated area of the state into water districts, each managed by a water commissioner, had its inception in the legislation of the year 1879. The creation of larger divisions, known as water divisions, was made in the year 1881 under an act to provide for the appointment of a state engineer, etc. Four water divisions were created in 1881, and two more in 1889. One was created by proclamation of the Governor in 1901. There are therefore now seven water divisions.

The office of superintendent of irrigation having general supervision over each division was not established until the act of April 4, 1887. The first section of that act (Sec. 2447, M. A. S.) provides for the appointment of superintendents of irrigation for each water division, with proviso that the Governor shall not appoint such official for any division until the Board of County Commissioners of some county included therein shall have adopted a resolution requesting such appointment.

The duties of superintendent are defined in the act. The second section (Sec. 2448, M. A. S.) was as follows:

"Said superintendent of irrigation shall have general control over the water commissioners of the several districts within his division. He shall, under the general supervision of the state engineer, execute the laws of the state relative to the distribution of water in accordance with the rights of priority of appropriation, as established by judicial decrees, and perform such other functions as may be assigned to him by the state engineer."

The third section (Sec. 2449, M. A. S.) provides that the superintendent of irrigation shall be governed by the statutes, and to better discharge his duties he is authorized to make other regulations to secure equal and fair distribution of water in his division in accordance with the rights of priority of appropriation, which regulations adopted by the superintendent shall be merely supplemental to and in aid of the general statutory provisions.

The fourth section (Sec. 2450, M. A. S.) gives the right of appeal to the state engineer from any order or regulation from the superintendent of irrigation.

The fifth section (2451, M. A. S.) requires the superintendent of irrigation to commence the discharge of his duties when the first water commissioner in his district is called out, and to continue to perform the same until the last commissioner therein ceases to be needed. It also provides for reports from water commissioners to the superintendent as heretofore noted.

The seventh section (Sec. 2453, M. A. S.) requires each

superintendent of irrigation within thirty days after his appointment, to send to the Clerk of the District Court in all counties in his division having jurisdiction over the adjudication of priorities, a notification of his appointment, and requesting a certified copy of every decree of the District Court establishing priorities of appropriations of water used for irrigation purposes. It is made the duty of such clerk to transmit such certified copy to the superintendents of irrigation, and that official is then required to cause to be prepared a register of priorities of appropriation of water for his division, based upon such decrees. He is then required to prepare a list of all the ditches, canals and reservoirs within his division, arranging the same in consecutive order according to the dates of appropriations in the whole division, and without regard to their number in each water district alone. He is also required to make a tabulated statement of all ditches, canals and reservoirs in his division, to whom such priorities have been decreed, containing in separate columns,

- (a) The name of the ditch, canal or reservoir.
- (b) Its number in the division.
- (c) The district in which it is situated.
- (d) Its number in its proper district.
- (e) The number of cubic feet per second to which it is entitled under each priority.
- (f) Such other and further information as he may deem useful.

The 8th section (Sec. 2454, M. A. S.) gives the superintendent of irrigation power to call out any water commissioner in his division at any time he may deem it necessary; also power to perform the regular duties of the water commissioner in all districts in his division.

The 9th section of the act of 1887 (Sec. 2455, M. A. S.) provides that all water commissioners in the division shall report to the superintendent of irrigation. The contents of said report have heretofore been referred to in discussing the powers and duties of water commissioners. In addition to the matters detailed in the statute, the superintendent of irrigation is authorized to call for such other and further information as he may suggest. Said official is required to file such reports, to ascertain how water is being distributed, and if as the result of the division into districts, ditches are deprived of water to which they are entitled in the division as a whole by some junior ditch in one district receiving water when a senior ditch in another district which can be supplied with the same water is not receiving its proper supply, then it is the duty of the superintendent to at once order the post-dated ditch, canal or reservoir to be deprived of supply so that the water will run down to the older ditch in the other district. This section specially enjoins upon the superintendent of irrigation to make orders to enforce the priorities of appropriation according to his tabulated statement of



priorities for the whole division, without reference to the district lines. The reports of water commissioners to the superintendent are required to be filed in the office of the state engineer.

In the 10th section (Sec. 2456, M. A. S.) it is provided that when the owner of any ditch, canal or reservoir in any district within the division fails to receive the regular supply of water to which he is entitled, its owner or manager may report the same to the water commissioner, and that official, if he finds it necessary, shall report by wire to the superintendent of irrigation, and said last named official shall thereupon, if he finds he can give such ditch, canal or reservoir a supply at the expense of a latter priority in another district, to enter orders accordingly.

In 1901 there was passed an act in relation to irrigation, found in Session Laws of 1901, pages 193 to 196.

Under the 1st section (p. 193), when the owner of any irrigation structure taking water from any stream fails to erect or maintain in good repair a suitable and proper headgate and measuring flumes or weirs at its point of intake, together with necessary embankments therefor so as to control the water at all ordinary stages, the superintendent of irrigation (or the state engineer), after giving ten days' written notice, is required to refuse to deliver to the owner of such irrigation structure any water until such owner shall erect or repair the headgate and measuring flumes.

The 2nd section (p. 194) pertains to the maintenance of measuring flumes or weirs to determine the amount and volume of water turned into one stream from another, or from a reservoir or ditch into a public stream to be again rediverted. When the owners of a ditch or reservoir so used fail and neglect to erect suitable and proper measuring flumes or weirs for the purpose mentioned, it is made the duty of the superintendent of irrigation (or the state engineer), after five days' written notice, to refuse to allow any water to be taken out from a public stream in exchange for water so turned into the same until the owner shall cause to be erected or repaired such flumes or weirs, both at the point of delivery to the stream and at the point of delivery of taking from the stream.

The 3rd section of the act (p. 194) requires the superintendent of irrigation (or the state engineer) to rate the measuring flume and weir referred to in first and second sections, and to supply the water commissioner of the district where such measuring flumes or weirs are located with a rating table to be used in measuring water.

The 5th section (p. 195) provides that all headgates and measuring weirs used in connection with any irrigation structure to measure and deliver water therefrom and thereto, shall

at all times be under the supervision and control of the irrigation officers of the state.

The 6th section (pp. 195-6) pertains principally to the duty of the owner of a reservoir situated upon or in the bed of any natural stream, to cause a survey to be made of the reservoir with contour lines for every vertical foot in depth, to be properly rated by the state engineer. In case of the owner failing to do what is required, the superintendent of irrigation (or the state engineer) is directed to refuse to permit the use of such reservoir.

#### COMMENTS ON THE POWERS AND DUTIES OF SUPERINTENDENTS OF IRRIGATION.

Evidently this office was created to relieve the state engineer of duties which otherwise might have been too onerous. It was deemed proper by the legislative department of the government to have a special officer in general charge of all the water commissioners in a single division. The duties of a superintendent of irrigation plainly arrange themselves into two classes. First, the duty to protect senior priorities irrespective of district limits; second, to exercise general supervisory control over all water commissioners in their ordinary discharge of duties. We will discuss these two powers separately.

1st. The power to enforce senior priorities from a main stream as against junior priorities from a tributary of such stream in a different water district, is absolutely necessary to carry out the doctrine of priority of appropriation, since the water of a main stream is practically the result of accretions from its tributaries. Before the enactment of the statute of 1887, there was no proper machinery through the regular water officials to enforce this requirement of the law. Even after the enactment of the statute, little was done until the matter received consideration by the Supreme Court in 1896. It is true that prior to that time, in the case of *Strickler vs. Colorado Springs*, 16 Colo. 61, reported in 1891, the Supreme Court had declared that any different doctrine would wipe out the principle of priorities upon which our whole system is based. As said by Judge Hayt in that case, "To say now that an appropriator from the main stream is subject to subsequent appropriation from its tributaries would be the overthrow of the entire doctrine."

Still it was not until the decision of the Supreme Court in the case of *The Farmers Independent Ditch Company vs. The Agricultural Ditch Company*, 22 Colo. 513, handed down May 18, 1896, that the legislation of 1887 had judicial construction. In that case the court, by Chief Justice Hayt, used the following language:



"The legislature, by the act of 1887, has attempted to solve the difficulty by providing an officer and making it his duty to distribute water according to the decrees rendered, without reference to the water district in which such decrees are to be found. As we have said, the act does not attempt to make such decrees conclusive as between the various districts, but, in effect, it provides that until the courts shall determine otherwise in some appropriate proceeding, the superintendent shall treat the decrees as *prima facie* correct and distribute water accordingly. We believe this regulation is fairly within the police power of the state, as defined in the case of *White v. The High Line C. & R. Co.*, *supra*, and that it violates no constitutional provision; the effect being only to require the distribution of water in a certain way until such time as the rights of the parties can be definitely ascertained and adjudicated."

Again, in the case of *The Lower Latham Ditch Company vs. The Loudon Irrigation Canal Company*, decided March 5, 1900, reported in 60 Pac. Rep. 629, it was held that the plaintiff having priorities in water district No. 2 from the South Platte river was entitled to a decree requiring the water officials to protect its priority, if necessary, at the expense of junior priorities, from the Big Thompson river, in water district No. 4.

In view of the rule of priority in time giving the better right, the statutes and the judicial decisions, it must now be regarded as beyond controversy that one of the principal duties of the superintendent of irrigation is, without fear or favor, to issue such orders as will enforce senior rights in one district, when they cannot otherwise be supplied, by cutting down the supply of junior rights in other districts on tributary streams.

In connection with this duty of a superintendent of irrigation some discretion must be exercised in determining to what particular water commissioner orders shall be directed, where there are many tributaries supplying the same main stream, having in view the location of the particular ditch needing relief, and the location of junior ditches from which its needs may be supplied. The prime duty of the superintendent is to furnish water to the senior appropriator in the main stream needing it. It may be that such senior appropriator is needing water at a time when thirty different juniors are enjoying water under several tributaries of the main stream and in several districts. In theory, the latest appropriation should be the first cut down, but if, in fact, that appropriator is forty or fifty miles away, and another junior is within a few miles, relief can best be given by depriving the junior on the nearest tributary. In practice, the latter course usually will be found to be necessary. The superintendent in such cases may be able to supply the needs of the senior appropriator by reducing to some extent a large number of juniors, thereby interfering less violently with the regular distribution of any particular district.

Another matter worthy of special note in this connection which must be considered by the superintendent of irrigation,

grows out of natural conditions. The writer was informed that on one occasion older ditches in the vicinity of the town of Sterling, in Logan County, were needing water when junior ditches in Morgan County were fairly well supplied, and that a large amount of water, by order of the superintendent of irrigation, was shut out of the junior ditches and required to run into the South Platte river in the month of July or August, when the heat was very great and there was very little water in the main stream, and it was found that all, or nearly all of the water thus taken from the junior ditches was lost by evaporation and otherwise in the sand beds of the South Platte river. In that particular instance, as reported, it was found practically impossible to supply the senior ditch. In 1901 another test was made in the same locality, resulting in large increase of supply, it is claimed, to ditches near Sterling. It is here suggested that in all such cases the superintendent of irrigation should not hastily jump to conclusions, but should in perfect good faith endeavor to supply the senior appropriator, and not refrain from so doing until convinced that natural conditions render it practically impossible.

2nd. The remaining class of duties devolving on a superintendent of irrigation pertain to his general control over the water commissioners in his division, his duty to execute the laws pertaining to distribution and in so doing to make rules and regulations, to carry on correspondence with all his water commissioners, and, at times, if necessary, actively to discharge the duties of a water commissioner. All suggestions made concerning the duties of water commissioners apply equally to superintendents of irrigation. If the superintendent keeps up a constant and active correspondence with all commissioners in his division and makes frequent suggestions to them concerning the proper discharge of their duties, he can be a great aid in reducing the whole work of his division to a more perfect system. By such correspondence he can learn how thoroughly each commissioner is discharging his duties; if complaints are made to him of inefficiency of service in some district, he can give the water commissioner thereof the benefit of his knowledge as to the more efficient conduct of some other water commissioner in another district. If suggestions by correspondence fail to remedy negligence or inefficient discharge of duty in some particular water district, he can, if he sees fit, himself perform the duties of water commissioner in that district for a short time, and thus by personal example give the water commissioner full knowledge of what is expected of him. The power conferred on superintendents of irrigation to obtain information from water commissioners on any subject pertaining to irrigation in his division as he may suggest, enables a brainy superintendent who desires to use the entire power of his office to improve and perfect the



system, to do much in that direction, to become a center from which radiates an energy and an influence which will make himself a potent factor in the perfection of the system, whereby the purpose and intent of the law will be carried out, and the best interests of the state and its agriculture be subserved.

Water commissioners and superintendents of irrigation, in carrying out the orders of the state engineer, and in aiding that official in the discharge of his duties, also will improve the efficiency of the system as a whole.

Incidental to all the other duties of a superintendent of irrigation there should not pass unnoticed his importance as a peace-maker and settler of petty disputes, which may arise in his division and the several districts thereof. Much unnecessary litigation doubtless has been and hereafter will be prevented by superintendents of irrigation on the line here suggested. A visit of that official to a water district in which a commissioner is having serious trouble and disputes with ditch owners has a wholesome influence leading to amicable adjustment of such controversies.

It has sometimes been believed that the office of the superintendent of irrigation was somewhat superfluous. Persons inclined to that view have taken the position that the state engineer, as the general center of authority and supervision of all water districts, would be sufficient. Development of agriculture and irrigation is such, however, and the other duties of the state engineer necessarily take so much of his time and attention that it would be difficult, if not practically impossible for any state engineer, however capable, fully to discharge the duties of all the superintendents of irrigation without being compelled to neglect other important duties of his office.

It is believed by the writer hereof that if the superintendents of irrigation constantly devote themselves to a study of the water distribution in their respective divisions and to the thorough and efficient discharge of all of the duties of their offices, both advisory, administrative, appellate, and corresponding, they can constantly be employed and become important factors in improving the water service of the state.

## THE STATE ENGINEER.

### POWERS AND DUTIES WITH REFERENCE TO IRRIGATION MATTERS.

In 1881 an act was passed providing for the appointment of a state engineer in Colorado and of his assistants, and for the establishment of water divisions. (Sess. Laws 1881, pp. 119 to 122). The first five sections of the act cover the matter of water divisions, and the remaining seven sections had reference to the office of state engineer or "state hydraulic engineer," and his duties. The last seven sections were repealed upon the en-

actment of a new statute on the subject in the year 1889. The original act (Sec. 6) gave the state engineer supervision over the water commissioners of the different water districts in the state. In section seven the state engineer was required to make careful measurements and calculations of the maximum and minimum flow of water in each natural stream from which irrigation ditches took their supply; also to collect facts and make report as to the system of storage reservoirs, and to keep full records of his work, observations and calculations. The tenth section required the state engineer to prepare and render yearly, and oftener if required, full reports to the Governor. The eleventh section required the state engineer, on request of any interested party, on payment of his expenses, to measure and ascertain the capacity of any ditch, canal or reservoir thereafter constructed or enlarged, and to give an official certificate concerning the same. The twelfth section provided that the owners of any ditch, canal or reservoir having decreed water priorities should construct and maintain, under supervision of the state engineer, measuring weirs to measure in cubic feet per second water at the headgate of such ditch, canal or reservoir, or as near thereto as practicable, and the state engineer was required to arrange in tabular form a computation showing the amount of water that would pass such weir in cubic feet per second at different stages or height of water therein, and to furnish copy thereof to the water commissioner interested.

The act approved March 30, 1889, pertaining to state engineer, repealed the last seven sections of the act of 1881, and in lieu thereof adopted eleven new sections still in force. This change removed all the qualifications formerly required. In the original act "no person shall be appointed as such hydraulic engineer who is not known to have such theoretical knowledge and practical skill and experience as shall fit him for the position."

The 1st section (Sec. 2458, M. A. S.) concerned the appointment and qualifications of the state engineer and other like matters.

The 2nd section (Sec. 2459, M. A. S.) gives the state engineer general specific control over the public waters of the state; requires him to make careful measurements of the flow of the public streams of the state from which water is diverted and to compute the discharge; also to collect data and information pertaining to the location, size, cost and capacity of dams and reservoirs to be constructed, similar data concerning the feasibility and construction of reservoirs on eligible sites on which he may obtain information; also data and information regarding the snowfall in the mountains each season to predict the probable flow of the water in the streams.

The 3rd section (Sec. 2460, M. A. S.) requires the state



engineer to approve plans and designs for construction and right of way of all dams or reservoir embankments in the state exceeding ten feet in vertical height.

The 4th section (Sec. 2461, M. A. S.) gives the state engineer general charge over the work of water superintendents and water commissioners, requires him to furnish them with all data and information necessary for the intelligent discharge of their official duties. It also requires the superintendents of irrigation and water commissioners to report to the state engineer at suitable times, and especially to make annual statements on blanks furnished by him of the amount of water diverted from public streams under their control and other statistics which he deems of benefit to the state.

The 5th section (Sec. 2462, M. A. S.) pertains to the duty of the state engineer, on the request of any party interested, on payment of his expenses, to appoint a deputy to compute and measure any canal, dam or reservoir or any construction of like nature.

The 7th section provides for the appointment of deputies by the state engineer, under his control, and for whose official actions he shall be responsible.

The 9th section (Sec. 2466, M. A. S.) enables the state engineer to request the owners of any ditch having decreed priorities to construct and maintain under his supervision measuring weirs at or near the head of such ditch, canal or reservoir. The state engineer is required to compute and arrange in tabular form any statement concerning the amount of water that will flow through such a weir at different stages, and furnish a copy thereof to any superintendent or commissioner having control.

The 10th section (Sec. 2467, M. A. S.) makes a cubic foot per second a unit of measurement of flowing water, and a cubic foot the unit of measurement of volume.

The 11th section (Sec. 2468, M. A. S.) requires the state engineer to prepare a full report of his work bi-ennially and to deliver the same to the Governor to be laid before the general assembly.

We have already noted that the fourth section of the act of April 4, 1887 (Sec. 2450, M. A. S.) gives the right of appeal to the state engineer from any order or regulation made by any superintendent of irrigation.

In 1897 an act was passed to provide for and to regulate the exchange of water between reservoirs and ditches and the public streams. (Sess. Laws of 1897, pp. 176-7.)

The 1st section requires the state engineer to determine what reasonable deduction shall be made for seepage and evaporation when a person or company shall divert water from one

public stream into another and then divert it from the latter stream.

The 2nd section requires any person or company so transferring water from one public stream to another to construct and maintain, under the direction of the state engineer, measuring flumes or weirs and self-registering devices where the water leaves its natural watershed and is turned into another, and also where it is diverted for use from the public stream.

In the 3rd section it is made the duty of the water commissioner of the district where the water is used, to keep a record of the water so turned into his district.

The 4th section permits, without injury to others, the owner of a reservoir to deliver storage water either into a ditch or into a public stream to supply early appropriations, and in exchange therefor to take from the public stream higher up an equal amount of water, with deduction for loss, if any, to be determined by the state engineer. The same section requires the person or company desiring such exchange to construct and maintain, under the direction of the state engineer, measuring flumes or weirs and self-registering devices at the point where the water is turned into the stream or ditch, so that the water commissioner may readily determine and secure a just and equitable exchange.

In 1899, an Act in Relation to Irrigation, adopted, had special reference to the matter of changing the point of diversion by an appropriator when it can be made without injury to the prior rights of others, and a judicial consideration in advance of the proposed change. In connection with the procedure, the state engineer is to receive and file a copy of the map and decree permitting the exchange, and thereupon to issue a notice to the water commissioner in charge, notifying him of the change. (Sess. Laws of 1899, p. 236, Sec. 2.)

Also in the year 1899 an act was passed in relation to reservoirs. (Sess. Laws of 1899, pp. 314 to 317.)

The 1st section provides that no reservoir of a capacity of more than 75,000,000 cubic feet, or having a dam or embankment in excess of ten feet in vertical height, and covering more than twenty acres shall thereafter be constructed, unless plans and specifications therefor shall first be approved by the state engineer. The state engineer is required to act as consulting engineer during the construction of such reservoir, with authority to require the work to be done to his satisfaction. A written statement concerning the work of construction and the completion thereof to his satisfaction must be given by the state engineer specifying the dimensions and capacity of the reservoir.

The 2nd section provides for the expenses of the state



engineer, and a per diem for his services to be paid by the reservoir owner.

The 3rd section requires the state engineer annually to determine the amount of water which it is safe to impound in the several reservoirs within the state. It is made unlawful for the owner of any reservoir to store therein water in excess of the amount determined by the state engineer to be safe.

The 4th section makes it the duty of the water commissioner to withdraw from any reservoir any water impounded therein in excess of the amount determined by the state engineer to be safe, and to prevent the reservoir to be refilled beyond the limit fixed.

The 5th section makes it the duty of the state engineer, when complaint is made to him by persons so located as to be in danger if the embankment of a reservoir should break, that the reservoir is in an unsafe condition, or being filled so as to render it unsafe, to make an examination of the reservoir and determine the amount of water which can be safely impounded therein. If on such examination he finds the reservoir unsafe, or being filled so as to render it unsafe, he shall cause water to be drawn off to such an extent as to render the same safe and prevent further storage of water beyond what he considers the safety limit.

The section enables the state engineer to use any force necessary to perform the duties previously mentioned. It is also made the duty of a water commissioner in such case, if an attempt should be made to refill the reservoir, to act as provided in the fourth section.

The 7th section provides for compensation to the state engineer for mileage and other expenses incurred in making examination.

The 8th section provides for an appeal to the court from any decision of the state engineer in such matters, but with the proviso that the decision of the state engineer shall control until the case is finally disposed of in the courts.

The 9th section provides for owners of reservoirs being responsible for all damages in case of breakage.

The 10th section provides that any reservoir company which after ten days' written notice has been given, fails to obey the directions of the state engineer with reference to the construction or filling of any reservoir, shall be subject to a fine of fifty dollars for each offense, and each day's continuance after the time of notice has expired shall be considered as a separate offense.

In addition to the duties required of the state engineer on the general subject of irrigation, distribution of water, etc., above referred to, many statutes have been passed requiring that of-

ficial be a member of divers boards of control of sundry internal improvements, to perform important services about state canals, with reference to desert land entries, and many other similar matters not pertinent to this paper except as showing how much of the time of the state engineer is necessarily invaded by other duties besides the important ones above indicated.

An act in relation to irrigation, passed in 1901, has been referred to at the close of the statement of powers and duties of superintendents of irrigation. All the powers conferred upon superintendents of irrigation by that act are also conferred upon state engineers. The sixth section of said act of 1901 (pp. 195-6) makes it especially the duty of the state engineer, on the request of the owner of a reservoir situated upon or in the bed of a natural stream, at the expense of the owners thereof, to cause a complete survey of the contour lines of said reservoir to be made for each vertical foot in depth, and also when he deems it necessary of fractions of a foot; also to prepare a table showing the number of cubic feet capacity of said reservoir for each foot in depth and fractions thereof, and to place a gauge rod in said reservoir, marked in correspondence with the contour lines. In event the owner fails to cause said survey, etc., to be made, it is made the duty of the state engineer to refuse to permit the reservoir to be used until such survey, etc., is made.

#### COMMENTS ON POWERS AND DUTIES OF THE STATE ENGINEER.

The mere recapitulation of the functions of the state engineer as the head of the system of irrigation and distribution of the state, his supervisory control of all water commissioners and superintendents of irrigation, his appellate jurisdiction over subordinate officials, his special duties with reference to the measurement of canals and reservoirs, his supervision and control over the construction of reservoirs, his duty to provide for self-registering devices in many instances, is sufficient of itself to make plain the responsibility of his office.

It is plainly within the intent and purpose of the statute that the state engineer must devote considerable time to a thorough study of the whole system of irrigation distribution of the state. In that connection he must become familiar with the work of the several superintendents of irrigation, and satisfy himself that they are properly performing the duties by law of them required. This also applies to the reports of the several water commissioners. As the state engineer is required to be a man of professional ability as an irrigation engineer, his advice and suggestions to superintendents of irrigation and water commissioners should be of special helpfulness. The result of his study



should enable him in his reports to make suggestions to the Governor, and thereby indirectly to the legislature on any desirable change in the law from time to time. His office has always been, and ever should be, of special importance in perfecting the efficiency of the official water service of the state.

The state engineer should insist on obedience to the statute law by persons constructing reservoirs, and by those who desire to exchange water between reservoirs and public streams, or to turn water from one public stream into another. Since the water commissioners are under the control of the state engineer, it is believed that it is within his power to direct water commissioners to refuse to recognize the rights of persons to divert water which is turned into a public stream from some other source of supply, unless the statute concerning self-registering devices and other legal requirements are complied with. The purpose of the statute is that exact justice may be done. The person who adds to the amount of water in a running stream by turning water therein from another stream or from a reservoir, should certainly be entitled to again draw the same amount of water from the stream as a just reward for his enterprise and capital invested. But on the other hand, every safeguard against abuse of this privilege, and to prevent the diversion to the injury of regular appropriators from the stream of a greater amount of water than is supplied thereto, after proper allowance is made for incidental losses, should be rigidly enforced.

Special comment should be made with reference to the importance of measuring weirs at the headgates or canals. It is unfortunately true and well known that when many of the decrees concerning priorities were rendered by the courts, sufficient care was not taken to have correct measurements made, whereby any ditches were decreed priorities really in excess of their carrying capacity. When for a large number of years it has been shown by experience, and as the result of careful measurement, that a ditch has not carried and cannot carry the amount provided in the decrees, sufficient data will be collected to prevent the subsequent enlargement of such ditch to enable it for the first time to carry the maximum mentioned in the decree, and thereby injuriously to affect the rights of junior appropriators. Moreover, such measuring weirs are of great value and aid to the water commissioners in distributing and apportioning the water at times of scarcity, and when ditches having several priorities limited to one or more of their earlier ones.



















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